SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FRIDAY, JANUARY 17, 1908

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A PLEA FOR THE BROADER EDUCATION OF THE CHEMICAL ENGINEER[1]

IT has become my duty, under a provision of the constitution of the American Association for the Advancement of Science, to mark my retirement from the office of vice-president and chairman of Section C by an address. Sir Boverton Redwood remarked on a recent occasion that such addresses offer an opportunity for the dissemination, from time to time, of highly specialized information. I might follow this custom and talk to you about one of the chemical industries in which I have specialized, but these subjects are of such limited interest that I shall avoid them and turn to one which appeals to me as being of the greatest importance at the present time, although, at first thought, it may seem to have received sufficient consideration of late, in view of the address of my predecessor in office, and many others, on the same and allied subjects. I believe, however, that no apology is necessary for asking your attention to the subject of the education of the chemical engineer, and this will include what he should be in the light of what he will be called upon to do, what characteristics he should possess, how he should be directed and encouraged, what training he should submit himself to in order to meet the demands which will be made upon him, and, finally, how his profession may be raised thereby to the level of the other learned professions such as

[1] Address of the vice-president and chairman of Section C—Chemistry—of the American Association for the Advancement of Science, Chicago meeting, December 31, 1907.

law, medicine and civil engineering, as exemplified by their most successful practitioners and representatives, since it is not too much to hope that it may, in the near future, be elevated to a place of due honor and prominence and given proper recognition in our national life, and that, eventually, the chemical engineer may fill many of the executive and administrative offices of our largest and most important industries.

That our industrial progress within the last half century has been phenomenal is too evident to require mention. Much of it has been based, however, on a very wasteful use of our natural resources, and, with their approaching exhaustion, reforms must be instituted and economies practised. There is a marked demand for an improvement in the quality of the output of some of our industries. The field for invention of new processes and new products is large. That the chemical engineer will play a large part in the development and regulation of the industries of the country along these lines can not be denied. It is already evident in what he has done in connection with the use of the electric current available at Niagara Falls and elsewhere. He has become, and will remain, the mainstay in certain particulars of the regulation and development of our many industries.

President Stone, of Purdue University, has said:

> True industrial progress consists in utilizing with ever-increasing economy and accuracy, natural forces and materials by more scientific methods of operation and management, in securing better conditions of life for industrial workers, in furnishing products of better quality at lower cost, and narrowing the gap between the employer and the employee.
>
> There comes a time inevitably when the mine is empty, the forest destroyed, the virgin soil exhausted. Then will arise the real question of industrial ability which can only be met by education and training.

As the chemical engineer will have a large part in solving this problem and as the demand for his services must increase to a great extent, it becomes an important question as to how he shall be selected, educated and trained to fill the rôle which he will have to play. It is this question which I wish to discuss to-day in the light of the opinions which have been expressed by others, and in that of my own experience, the latter being that the graduate of our technical and scientific schools who proposes to adopt the career of chemical engineer is the product of a too narrow training, being at the best an expert chemist, and in no sense fitted to deal with affairs or impress himself upon others. My plea will be for a broader education for the young man who proposes to become a chemical engineer, and for avoiding the making of the intense specialist with his narrow point of view and lack of culture. My remarks will be addressed as well to the young man who is contemplating entering upon such a career, or is already in preparation for it, as to those who will be responsible for his training, or, as industrialists, look forward to the advantages to be derived from having available broad-minded, liberally educated and cultivated men who are, at the same time, chemists and men of affairs, and, as such, fitted to take part in the development of our industries.

We must formulate our idea of what constitutes a chemical engineer. In my opinion, a chemical engineer is, primarily, a chemist, but essentially a man of affairs and executive ability who is engaged in the application of the principles of chemistry in the arts and industries, with special reference to the commercial development of the industries and establishment of new ones, to perfecting the arts, and by his advice and cooperation, assisting other engineers in the practise of their professions.

There are, of course, many types of chemical engineer: the inventive type, in some ways the highest; the type which adapts and makes practicable the discoveries of the inventor; the administrative and economic type, which is that of a large number of the profession; the constructive type, dealing principally with the design and construction of apparatus and plants, and approaching more nearly the civil and mechanical engineer, and, finally, the advisory type, which is engaged almost entirely in a consulting and inspecting capacity, and who more nearly resembles the counselor at law and is closely allied with him in litigation involving facts or opinions which must be interpreted in the light of chemical principles or experience. The type into which any individual may develop will depend upon his temperament and aptitude and upon the opportunities which he may have opened to him.

The mere technologist or industrial chemist is often confused with the chemical engineer, but should be sharply distinguished from him. The former is merely acquainted with the details of the various arts and industries, as they are carried on at present, and he sees that they are properly conducted according to rule and custom. He does not originate, nor does he study them from the point of view of the chemical investigator. He is more nearly an empyric. He is unable to meet the demands which are made upon the chemical engineer, or to take a leading part in the affairs of the world.

The chemical engineer must not be content to remain a mere technical man. He must be practical. As President Humphrey has remarked of the civil engineer: "His work must be based upon correct and complete theory, but it must be, first and last, practical," while Professor John Perry calls attention to the fact that:

> He must have all the knowledge of the scientific man, and ever so much more. He uses the methods of the scientific man and adds to them methods of his own. . . . They come to him through a very wide experience of engineering processes, of acquaintance with things and men.

We should have in the chemical engineer, at once, the thorough chemist, the man of imagination, the leader of men who inspires confidence in those about him. He should be an executive of the first order, who, having an eye for the selection of others of a capacity for special duties, is able to direct them so as to obtain the greatest return from their services. He should not waste a moment's time in doing anything which another can do equally well, and should reserve all his energies for the higher problems which may be met. He should have tact in dealing with others, and, in particular, should be able to express himself by word of mouth and in writing in a forceful manner, that is to say, he should have command of the English language and some literary capacity. He should also have a knowledge of German and French so that the scientific literature of these countries may be available to him and enable him to keep in touch with the specialists who are at work there in his own and allied professions. He must be at all times a student and a wide reader. He should not neglect research and should inspire his subordinates with the necessity of it for the prevention of that tendency to fall into a rut which is so common. He should be a man of personality to enable him to make a favorable impression upon those with whom he is brought in contact. He should avoid all antagonisms and should only permit himself to indulge in destructive criticism on rare occasions. Above all, he should possess initiative, imagination and perspective. He should be a person of original ideas and not a mere follower of those of others. He should not be afraid of the improbable and the unlikely, and, in this respect, may well

take to heart the advice of Sir William Ramsay.

For the making of the successful chemical engineer, as for other professions, the best material only is suitable, if the result is to be more than mediocre. Unfortunately, the human race is not bred to points, either physically, mentally or for special aptitudes, in the same way that is practised with the race horse, with high-grade cattle or dogs, to develop their most desirable characteristics; the importance of national eugenics has only recently been brought to our attention by Galton and Pearson. We have recourse, therefore, only to what chance may produce. Nevertheless, chance has done much for us. Professor H. E. Armstrong calls attention to the fact that:

> Americans may be said to be a distinct if not an improved breed. Certain proclivities have been, undoubtedly, unconsciously selected out and there has been much cross-breeding; hence a race has developed differing in important respects in its type of thought if in no other way, from those represented in Europe. Moreover, success has given them belief in themselves, and leads them to trust themselves.

We should make our choice of those youths who have had the best of home discipline and restraint. Sir John E. Gorst calls attention to the fact that:

> The chief causes which produce formation of character are met with in the homes of the people.

The individual who has been subjected to the most favorable environment in his early years and in the secondary schools will be the most satisfactory, if he possesses the proper aptitude to be a chemical engineer.

Aptitude, or what is sometimes denominated a natural gift, is inborn and must be sought out. It can not be developed, but may be encouraged and directed. Professor A. Lawrence Lowell, of Harvard, has wisely said that the problem of the schools is to discover and stimulate the right kind of men more than to directly instruct them. There is too great a tendency to attempt to make chemical engineers out of all who have a fancy for dabbling in a laboratory. For this reason, it seems to me, a great responsibility rests upon our schools in guiding the youth into proper channels and restraining him from fields where he can only meet with disappointment.

Taking what chance may offer as regards breeding, and chance at times offers very good material if we exercise selection, we must endeavor to impart direction from the earliest years of the individual's training.

> It is for wise direction that the coming generations cry; and it is our business to see that they get it,

as the man of science remarks in "A Modern Symposium."

In our secondary schools there is too little consideration of the individual or of his direction. There is too much routine, too much system and uniformity. The bright and the dull boys are advanced through the various grades at the same rate. What we need is, as stated by President Eliot, the promotion or advancement of each pupil by subject and not by mere time. By the present system, much time is lost to the bright boy. Individuality, and not uniformity, should be the rule in all branches of education, and particularly in the case of those who propose to become professional men. Dr. Böttger appreciates the situation in our American high schools when he says:

> In America one finds the object of the high school instruction to be to enlarge the capacity of the average man, while in Germany the main object is well known to be the complete development of the best student.

While this object is a praiseworthy one as applied to the average man in America, it is not satisfactory in the case of those who propose to follow a professional career. President Remsen, however, in reviewing

Böttger's book, thinks that while it may be true of our colleges and technical schools, it is wrong as regards the graduate work of our universities, and this is probably true of our graduate schools of the higher class, but plainly not so in those which turn out some of our weaker doctors of philosophy.

Hugo Münsterberg points out, in a way well worthy of consideration, some of the faults of our secondary educational system. He says:

I do not want to be misunderstood as seeing no fault in the American system of instruction. There are not a few wrong tones which hurt the ear of the newcomer, discords to which he will never become insensible. But these fundamental errors belong to the school rather than to the college. It is enough to point out the most devastating one; the lack of mental discipline at the very beginning of the intellectual growth. The school methods appeal to the natural desires and do not train in overcoming desires; they plead instead of commanding, they teach one to follow the path of least resistance instead of teaching to obey. The result is a flabby inefficiency, a loose vagueness and inaccuracy, an acquaintance with a hundred things and a mastery of none. Public life has to suffer for it, a community which does not get a rigid mental discipline through home and school influence must always remain the plaything of the lower instincts.

How much more the American college might have been able to produce if it could have received into its freshman class young disciplined minds, trained in accurate and careful learning and in the restraint of primitive impulses. The college would not have been burdened by wasting much of its costly time in repeating the elements of learning and patching up the slang-disfigured English language.

Professor C. A. Waldo, in his vice-presidential address before Section D of the American Association for the Advancement of Science at St. Louis in 1903, on "The Relation of Mathematics to Engineering," said, dealing with the question of our preparatory schools:

This is the indictment of the schools, that they use, largely to the exclusion of the thought element, a mass of formal and conventional educational material and thus paralyze thought and make abortive any natural mental growth.

Professor J. J. Stevenson remarks (*Popular Science Monthly*, January, 1904):

The old adage says: "He who would command must first learn to obey." That American lads are sorely in need of such training is only too evident. . . . Such training means—training to think, to reason. Lads often fail to receive this training in secondary schools, as any instructor who has had to deal with freshmen can testify. Secondary schools to-day are little better than cramming houses to fit pupils to answer odds and ends of questions in papers for entrance examinations. Loose training and restlessness under restraint characterize the American students in the lower classes at college; lack of home training may be in part responsible for the latter characteristic, inferior teaching in secondary schools for the former.

There is much of truth in the preceding assertions. Our secondary and high schools are unsatisfactory. They offer to the colleges a mass of more or less unformed material which must be worked over again at great loss of time and energy. It is evident, therefore, that one of the first steps in the improvement of the education of the chemical, or, in fact, of any engineer, lies in a modification of his early training.

If we can not expect as much as might be desired from the secondary schools, we may at least study the material that is offered, selecting and directing that which is most suitable for encouragement, but we must not force the crude product into the professional schools. That, it seems to me, is the great crime of to-day, especially in the case of those who propose to become engineers of any type.

What provision can be made to avoid these difficulties? I believe this lies in postponing professional training except in so far as elementary science may form a part of any ordinary liberal education, until a proper foundation can be laid for it. We do not find at universities of the

highest standing that students are received into the schools of law or medicine until they have prepared themselves for the study of these professions by a liberal education involving the taking of a bachelor's degree, which is accompanied by the attainment of the necessary degree of maturity. Is chemistry as a profession one which does not need the same foundation? In my opinion, this is not the case. A sound foundation is quite as much needed as in law or medicine.

The subject has been discussed, pro and con, at great length in numerous recent addresses. Professor George F. Swain, in opening a discussion on engineering education before the American Society of Civil Engineers in 1906, said:

> Most people will admit to-day that civil engineering, like other branches of engineering, belongs to the learned professions, and should require a preliminary training corresponding to that necessary for the lawyer or physician.
>
> The trouble with the young man between the ages of sixteen and twenty-two, who is given the opportunity of a higher education, is that he fails to realize his opportunity and does not take advantage of it, and, as a result, many of the graduates of technical schools and colleges have neither accurate knowledge of any one subject, nor the ability to think clearly and logically, nor the power of taking up a new subject and mastering its fundamental principles without assistance. . . .
>
> In laying out an engineering course, the aim should be, first of all, to develop broad-minded men who can observe correctly, reason logically, express themselves in language and on paper, men with imagination and with character, and with good physical development.

He adds:

> Studies which involve discipline of the mind and observation should be preferred to those which merely give information.
>
> Subject to the above restrictions, what is taught is not as important as how it is taught.
>
> The choice of a profession should be made as early as practicable and a continuous course should be arranged with that profession in view from the beginning of the higher education.

Professor Hugo Münsterberg in a recent address at Lafayette College, already referred to, in which he sings a song of praise for the American college and advocates the establishment of one in Germany at Hamburg, says:

> The idea was that in Hamburg, just as in Harvard, the youth ought to get in common, in years of academic freedom, the inspiration of cultural work in history and economics, in literature and philosophy, in art and natural science, before their ways are divided to go either to the professional schools of the typical German university or to the practical enterprises which commerce or industry or agriculture or politics may offer.
>
> That which is needed for the Germany of to-day, and still more for the Germany of to-morrow, is an academic institute of a new type—a university where the full freedom of academic life can be joined to studies of a purely cultural character, where young men may enter two years before they have reached the present goal of the professional university, and where a three or four years' course would prepare them for the duties of life without any thought of their later occupation.

He adds that in America:

> Public opinion was thus imbued with the correct idea that these professional studies did not in themselves guarantee a high level of culture. The real culture, on the other hand, the making of a gentleman, was left to the college. . . . The highest professional schools to-day demand the bachelor degree at their threshold.

If Professor Münsterberg demands something of the sort for Germany, why should it not be put to greater use in the education of our chemical engineers in this country, where it can be had for the asking?

The board of visitors to the Military Academy at West Point for the present year appreciated the necessity of overhauling the curriculum at that institution, with a view to bringing about a broader culture, the course now evidently being too intensive. The board states:

> An officer of the army should be an all-around educated gentleman. As it is now, his entire training, both preparatory at the academy and postgraduate, is almost purely technical,

and within a few weeks President Schurman, of Cornell, has emphasized the impor-

tance of such considerations in his annual report for 1906–7.

In an address, well worthy of careful consideration, before the graduating class of the Rose Polytechnic Institute in 1903, Dr. C. E. Mendenhall, of the University of Wisconsin, discussed the subject of whether the technical education there given compared favorably with the so-called liberal education of the regular college or university. He concludes:

> It is apparent, then, that technical education, as at present understood, is strong in the matter of the discipline of the mind and will; it will help a student to think clearly; it will give him self-confidence and self-control, and teach him the virtue of the necessity for work. It is equally apparent that the system is weak on the side of broad general knowledge and cultivation, and there is no doubt that this is a serious defect.

And after discussing various remedies for the situation, he adds:

> In ways like these will it become more and more true, let us hope, that the engineering graduate has had the essential features of a liberal education in addition to his professional training.

He asks the question:

> But do we fully grasp the fact that we are called upon to be broad men as well as specialists, and that there is a sort of success to be attained quite distinct from our professions?

The president of Case School, in his inaugural address in 1904, said:

> It [a technical course] does not teach him all that an educated man ought to know. It would be much better if our technical graduates were broadly educated men as well as trained engineers, if they had received a college training before entering on a technical course. . . . I believe the student should be trained to know, to search, to think, before he enters the technical school. During his whole life he would have a broader outlook, a deeper sympathy with men and events, a greater influence upon the community. I am sure he would be a better engineer.

President James, in his inaugural address on assuming the office of president of the University of Illinois, in 1905, said:

> The university is the institution which furnishes a special professional, technical training for some particular calling. This special, technical, professional training must, however, be scientific in character and must be based upon adequate preliminary preparation of a liberal sort.
>
> By this requirement of a liberal preparatory training, the university is differentiated from the technical school or trade school of secondary grade.

In the light of the preceding statements, it would seem that my plea for a broader education of the man who is to adopt a professional career has been supported very generally by those who have given the subject consideration. The requirements of the Harvard Schools of Medicine and Law are recognized as applicable to other professional schools, and in this respect I am putting forward nothing novel. I believe, however, that but little has ever been said in regard to the necessity of a similar requirement in the schools where our chemical engineers are trained, although an equal necessity, in my opinion, exists. I am ready to grant that the individual who proposes to follow the career of an investigator in pure science may, perhaps, succeed by specializing from his earliest years, but it can not be granted in the case of the engineer who must train himself as well to deal with men and affairs as with his strictly professional subjects. The question, of course, always arises as to what the education shall be of those who are to occupy places of minor rank, and form the rank and file of industrial chemists, but who will never attain eminence as chemical engineers. Here a good education is demanded along technical lines alone, and in the more narrow field little else is called for. Our technical schools can accomplish this work, but there is always danger that the graduate may be led to think that his degree, without any regard to his natural abilities, will lead him to the higher places in the profession, and, when he finds that he is not the great success that he has pic-

tured to himself, he blames the system of education, and not entirely without cause. There are too many graduates of the technical schools, especially of the middle west, who are spoiled by being educated beyond their capacities. They would be better off with a good high school education and with a trade. This, however, is a different problem from that which we are considering. What we must take up is: how can the student of sufficient capacity obtain the training and education for which I have pleaded? It will, of course, involve the expenditure of more time and money than if the mere technical training is sought. If time and money are insuperable objections, the more satisfactory course must be abandoned, and reliance placed upon the possibility of making up the deficiencies in the school of application in after life. It is my belief, however, that great efforts should be made to follow the course which I have laid down. On its completion, the man will find himself a more matured and better informed person, he will have greater confidence in himself, he will make a better impression on those with whom he comes in contact, and will command a greater remuneration. He will find that he is well repaid for the effort which has been made. Of course, in the case of the individual who is not hampered for means or time, there can be no question, for the same reasons, as to what to do.

It has not been the usual course for the chemist as yet. It approaches more nearly to that of the college graduate who, with the A.B. degree, spends three or more years in obtaining a Ph.D., and, as far as a knowledge of chemistry is concerned, such a course would be satisfactory. As Professor L. M. Dennis has remarked:

> There should be no distinction between the training of the technical chemist and one who is to devote himself to pure science and investigation.

The chemist who is to become a chemical engineer, however, must also be equipped in other ways which can not be done in the mere attainment of a doctorate. He must acquire his professional attainments in a different school and atmosphere. He must perfect himself in allied subjects and be competent to cooperate with other engineers.

My own idea is that the plan offered by Harvard will furnish the most desirable training for the chemical engineer, whether practised at that university or elsewhere. At Harvard, on the point system, a liberal education and the bachelor's degree can readily be attained in three years by one of slightly more than average ambition. During these three years he will have been subject to an environment which will mature and broaden him if there are any broad qualities to be brought out. He will find himself and his capacity, and how to direct himself. He can, in addition to the liberal courses which he may take, select such others as will enable him to satisfactorily enter the graduate school of applied science and to there pursue his technical studies. He is in a position to take up the professional work of the school with every probability of approaching it as a mature and well-balanced man. Two years in this school is rewarded with the degree of master of science in chemistry, and the graduate is then ready for more advanced studies or for entrance into the final and great school of application.

At the present time the number of students in the graduate school of applied science at Harvard is sixty-three, of which, I regret to say, only one is a student of chemistry. This is not large as compared with many of our scientific and technical schools, but the quality of the men enrolled, and the number of undergraduates in Harvard College who look forward to entering this school later, and are planning their work to that end, is so large that the cor-

poration of Harvard is entirely satisfied with the experiment that it has made. It is, in fact, so well satisfied that within a few weeks it has definitely committed the university to the policy of placing the technical work in the university on a graduate basis, and it has closed the Lawrence Scientific School to the further admission of new students.

It is evident, therefore, that Harvard University has made a very great step in advance along the lines which I have suggested for the preparation of the individual for professional studies and fitting him to become a chemical engineer. It seems to me that it will acquire the same reputation from its move in this direction as it has in its law and medical schools.

At Columbia a similar course can be pursued, taking the B.A. in the college or the B.S. in the scientific school after four years' study and then proceeding in two years to the degree of chemical engineer.

Johns Hopkins has a graduate school of applied science, largely devoted to research, while in 1903 the Massachusetts Institute of Technology issued a prospectus for a graduate school of engineering, leading to the degree of doctor of engineering, which has not, as yet, materialized to any great extent, but which we may hope to see encouraged under the direction of the present acting president of the institute, our colleague, Dr. A. A. Noyes.

There are, no doubt, equally satisfactory opportunities in other schools for such a training as I have demanded, if the desire for it is expressed, and I would by no means suggest that continuous study in any one locality is necessary or even desirable.

The instruction in some of our schools is intensive, in others, broad. In one, the student meets an environment which is purely local, in so far as all, or the majority, of the instructors are graduates of the school in which they teach. In another, they have been assembled from a wider field, have brought to the school a broader conception of the science, and a more liberal point of view. The latter is surely the more desirable. It is quite possible, therefore, that it may be as well to move from place to place for the change of atmosphere which may be obtained.

The main thing to be accomplished is the making of the liberal-minded man of broad intelligence who shall possess those qualities which I have cited as being necessary in the chemical engineer and which, in my opinion, are not found in the graduates of our technical schools as they are now thrown on the world.

If time and my confidence in your patience permitted, I might go at length into some other defects in our system of educating the chemical engineer, more especially as to the evils of examinations and of making undue exertions to obtain degrees. But these subjects must be reserved for another time and place. The views of many prominent persons in regard to them are well known to you, and I may add that I am in sympathy with the idea that they are both evils which need very careful consideration.

It is to be hoped that the suggestions which have been made, although in no way novel, may, by reiteration, arouse some attention in so far as they may point out a way of making the chemical engineer of the future a larger, broader and more influential man than he is to-day, and one who will occupy a position in the community of as great importance as the leaders of the other great professions.

CLIFFORD RICHARDSON

THE MECHANISM OF HEREDITY[1]

HEREDITY is to-day the central problem of biology. This problem may be ap-

[1] Address of the vice-president and chairman of Section F, Zoology, American Association for the Advancement of Science, Chicago meeting, 1907–8.

proached from many sides—that of the breeder, the experimenter, the statistician, the physiologist, the embryologist, the cytologist—but the mechanism of heredity can be studied best by the investigation of the germ cells and their development. Although many phenomena of inheritance may be discovered in the absence of any definite knowledge of the mechanism of inheritance, a scientific explanation of these phenomena and practical control over them must wait upon our knowledge of their causes. Only a beginning has been made in this study and it seems probable that it may engage the attention of many future generations of biologists, but, nevertheless, we have come far since that day, only about thirty years ago, when Oscar Hertwig first saw the approach and union of the egg and sperm nuclei. Indeed, so rapid has been the advance of our knowledge within this field that it is hard to realize that this entire period lies well within the lifetime of most of those here present, and that many of the pioneers in this work are still active in research.

In the short time at my disposal I can not present even the briefest summary of the many important discoveries in this field; I can hope only to discuss a few of the most suggestive facts and theories as to the mechanism of heredity.

I

Heredity, which originally meant heirship, or the transmission of property from parents to children, has come to mean "the transmission of qualities or characteristics, mental or physical, from parents to offspring" (Century Dictionary). These qualities are frequently regarded as independent entities or "unit qualities," which are "transmitted" from one generation to the next through the agency of an "inheritance material" or "bearer of heredity." Such terms are not without fault when used merely as figures of speech, but when interpreted literally, as they frequently are, they are altogether misleading; they are the result of reasoning about names rather than facts, of getting far from phenomena and philosophizing about them. The comparison of heredity to the transmission of property from parents to children has produced confusion in the scientific as well as in the popular mind.

It is only necessary to recall the most elementary facts about development to recognize that in a literal sense parental characteristics are never transmitted to children. Every new individual is only a detached portion of an old one, and whether derived as bud, or spore, or egg, it owes its similarity to its parent to the fact that it was once a part of it, and not to something which has been "transmitted" from one generation to the next. Furthermore, from its earliest to its latest stage an individual is one and the same organism; the egg of a frog is a frog in an early stage of development and the characteristics of the adult frog develop out of the egg, but are not transmitted through it by some "bearer of heredity."

Indeed, heredity is not a peculiar or unique principle for it is only similarity of growth and differentiation in successive generations. The fertilized egg cell undergoes a certain form of cleavage and gives rise to cells of particular size and structure, and step by step these are converted into a certain type of blastula, gastrula, larva and adult. In fact, the whole process of development is one of growth and differentiation, and similarity of these in parents and offspring constitutes hereditary likeness. The causes of heredity are thus reduced to the causes of the successive differentiations of development, and the mechanism of heredity is merely the mechanism of differentiation. The peculiarity which distinguishes the differentia-

tion of the egg cell from that of any tissue cell is the fact that the latter gives rise only to a particular type of cell, with the formation of which differentiation comes to an end, whereas the former undergoes a long series of differentiations and gives rise to a complicated organism.

II

The causes of differentiation, and hence of heredity, are in general twofold, intrinsic and extrinsic; the former are represented by the germinal protoplasm, the latter by practically all other conditions. Similarity of differentiation in successive generations, or hereditary likeness depends upon similarity of both the intrinsic and the extrinsic factors. The differentiations of the germ follow a definite sequence because the substance of the germ undergoes definite chemical transformations, which are predetermined by its initial constitution. Similarity of sequence is involved in similarity of germinal substance and of environment.

There are no vital structures or functions which are absolutely independent, self-acting, self-moving, self-differentiating or independently variable. Each part and function exists only in close relationship with other parts and functions and with environmental conditions. Many of the criticisms which have been recently brought against "unit characters," "units of heredity," "organ-forming substances," "individuality of the chromosomes," indeed against heredity and variation as a whole, are applicable only to extreme views, which no one consciously holds. To be sure, an individual, whether a unit quality, a chromosome, a substance or a person, can not exist apart from its environment, but who has ever maintained the contrary?

A study of the phenomena of development, no less than the principle that every effect must have an adequate cause, makes it certain that the characteristics of an organism are in some way predetermined within the protoplasm of the fertilized egg cell. From a frog's egg only a frog will develop, from an echinoderm's egg only an echinoderm, and the course of development is, under constant external conditions, marked out in each case, even down to the minutest details. Since, however, these external conditions may be exactly the same in the case of two eggs, and yet the results of development be very different in the two, we can only conclude that the physical basis of inheritance is to be found in the properties of the germinal protoplasm. To assume that extrinsic causes determine whether there shall hatch from an egg a chicken or an eagle would be the sheerest nonsense. The fact is there is no escape from the conclusion that all really inherited characteristics are predetermined in the structure of the germinal protoplasm. But it should be observed that to say that characteristics are predetermined is a very different thing from saying that they are preformed. The one merely affirms that the causes of the transformations which lead from one step to another in the development are determined by the initial constitution of the fertilized egg; the other affirms that these transformations have already taken place within the egg.

III

It is practically certain that in the last analysis the characteristics of the germ are dependent upon its chemical and physical constitution. Fick has lately maintained that not only the protoplasm of every species, but also that of every individual, must be different from that of every other. At the same time he points out the fact that this apparently stupendous assumption is readily possible within the limits of the composition of protoplasm, since Miescher has shown that a molecule of

albumin with forty carbon atoms may have as many as one billion stereoisomers. Reichert and Brown[2] have recently found that many genera and species of vertebrates may be distinguished with certainty by the properties of their hæmoglobin crystals. Here is positive proof that the molecular constitution of at least one important substance differs in different species, and if this be true of hæmoglobin it may be safely assumed to be true of the constituents of the germinal protoplasm.

For the present, however, we must be content to find the distinguishing characteristics of different germ plasms in their morphological and physiological properties rather than in their molecular constitution. And fortunately for the possibilities of research the morphological and physiological characteristics of the germ cells are sufficiently numerous and evident to afford a most fruitful and fascinating field for research.

In practically all theories of heredity it is assumed that there is a specific "inheritance material," distinct from the general protoplasm, whose function is the "transmission" of hereditary properties from generation to generation, and whose characteristics, as compared with the general protoplasm, are greater stability, independence, and continuity. This is the Idioplasm of Nägeli, the Germ-plasm of Weismann. It is further assumed that this germ plasm is itself composed of ultramicroscopical units, which are capable of undergoing transformation during the course of development into the structures of the adult. These are the hypothetical Plastidules, Gemmules, Pangenes, Plasomes, Idioblasts, Ids, Determinants, Biophores of various authors. However necessary such units may be for a complete philosophical explanation of development, it must be confessed that at present they constitute a purely hypothetical system which may or may not correspond to reality. We know that the germ cells are exceedingly complex, that they contain many visible units such as chromosomes, chromomeres and microsomes, and that with every great improvement in the microscope and in microscopical technique other structures are made visible which were invisible before, and whether the hypothetical units just named are present or not seems to be a matter of no great importance, seeing that, so far as the analysis of the microscope is able to go, there are differentiated units which are combined into a system—in short, there is organization.

On the other hand the evidence in favor of an inheritance material, which is distinct from the general protoplasm of the germ and whose function is the reproduction of hereditary characters, is not convincing. All the living substance of the egg cell is converted by growth and differentiation into the mature organism. That there is a species plasm, or an individual plasm, which is continuous from generation to generation, and from which all the qualities of the mature organism are differentiated, is almost a certainty, but there is no satisfactory evidence that this substance is distinct from the general protoplasm of the young germ cells.

IV

Differentiation, and hence heredity, consists in the main in the appearance of unlike substances in protoplasm and their localization in definite regions or cells. Such a definition is as applicable to the latest stages of differentiation, such as the formation of muscle fibers, as it is to the earliest differentiations of the germ cells, and the one is as truly a case of inheritance as is the other. In short, different sub-

[2] By the kindness of the authors I am permitted to refer to this very important research which will soon be published by the Carnegie Institution.

stances appear at an earlier or later stage in the development of all animals, and these substances are then sorted out and localized; this is differentiation. Physiological division of labor involves morphological division of substance; sorting out of functions implies sorting out of the material substratum of functions.

Unfortunately, we do not know many of the steps by which different substances appear within protoplasm. Even the formation of non-living products, such as oil, yolk and secretions, is but imperfectly understood, while the manner of formation of different kinds of protoplasm is almost wholly unknown. No one doubts, however, that different kinds of protoplasm are formed in the course of development, that the substance of a muscle cell, for example, is different from that of a nerve cell, and that both are different from the germinal protoplasm; furthermore, no one doubts that the relatively few substances of the germ cells give rise through many transformations to the relatively numerous substances of the adult.

But although little is known regarding the method of origin of the different substances which appear in the process of differentiation, in all cases which have been carefully studied one significant fact appears, viz., the importance of the interaction of the nucleus and cytoplasm. It is well known that many differentiations first appear in the immediate vicinity of the nucleus; indeed, in many cases various substances have been seen to come out of the nucleus and to mingle with the cytoplasm, while the nucleus in turn absorbs substances from the cytoplasm. It is known that constructive metabolism, differentiation and regeneration never occur in the absence of a nucleus. On the other hand, Verworn has shown that the nucleus alone is incapable of performing these functions, and he maintains that the chief rôle in the life of the cell can not be assigned to either the nucleus or the cytoplasm, but that both are concerned in vital phenomena. Judged merely by the results of observation and experiment, and wholly apart from current theories, it must be admitted that there is good reason to believe that the different substances which appear in the differentiation of a tissue cell arise through the interaction of the nucleus and cytoplasm, and not from either of these alone.

Turning now to the differentiations of the fertilized egg cell, we find that essentially the same conditions obtain as in the differentiation of a tissue cell. Here, also, different substances appear in the egg cell and become localized in different regions of the egg or embryo. In most animals the different kinds of substance in the unsegmented egg are not numerous nor conspicuous, though in all cases so far studied at least three kinds of substance may be separated by means of the centrifuge. Here, as in the case of the tissue cells, it is known that there is an active interchange of nuclear and cytoplasmic substances. In the long growth period of the egg the nucleus grows enormously, evidently at the expense of substances received from the cell body. On the other hand, it is well established that substances issue from the nucleus into the cell body and mingle with the cytoplasm during this stage, and it is generally believed that one of the substances thus formed, the yolk nucleus, is instrumental in the formation of yolk. At the end of the growth period of the egg the nuclear membrane dissolves and a relatively enormous quantity of nuclear material is thus liberated into the cell body, while an insignificant quantity persists in the form of chromosomes and gives rise to future nuclei. During every cleavage of the egg the nucleus grows by absorbing substances from the cell body, only to give back other sub-

stances to the cell at every mitosis, thus constituting a sort of systole and diastole of the nucleus, and it may be suggested that this interchange between nucleus and cytoplasm is one of the primary functions of mitosis. Many of the substances which are liberated from the nucleus are visibly different from the other substances of the cell body, and in some cases they may be traced through successive stages of development until they give rise to particular portions of the embryo.

The time at which particular embryonic differentiations appear differs widely in different animals. In some cases the earliest visible differentiations which may be correlated with the later differentiations of the embryo or larva, appear about the time of the formation of the blastula or gastrula, and here the cleavage cells are apparently all alike. In other cases the cleavage cells are not alike; even the first cleavage, as well as the later ones, may be of differential value, thus giving rise to cells which differ in size, symmetry and substance, and these features of the cleavage are inherited as certainly as are the form and character of the larva or adult. In still other cases marked differentiations of the egg are visible before cleavage begins, while in some instances these differentiations are present even while the eggs are still in the ovary.

But whether these differentiations appear early or late, there is reason to believe that the processes by which they arise are essentially the same in all cases, and that there is therefore no fundamental difference between eggs which differentiate early and those which differentiate late. It is quite possible that the time of appearance of differentiations depends less upon the time of formation of different substances in the egg than upon the time of their localization or segregation in specific regions or cells. All eggs hitherto examined show certain differentiations of the cytoplasm even in the earliest stages, though in most cases the different substances are not segregated before the cleavage stages. When such eggs are submitted to a strong centrifugal force the substances of the unsegmented eggs of practically all animals may be separated into at least three zones, which correspond in a striking manner to the three zones which are normally present in the unsegmented eggs of ascidians. This indicates that the real difference between eggs which are highly differentiated and those which show little or no differentiation of the cytoplasm may be in the segregation of unlike substances rather than in the presence or absence of such substances.

Regarding the other factor of differentiation, viz., the segregation or localization of unlike substances, rather more is known than in the case of their origin. Segregation of the different substances of the unsegmented egg and of the cleavage cells is known to take place chiefly by protoplasmic flowing, the direction of the flow being correlated with the initial polarity of the cell, and with the chemotropism of the substances concerned. Segregation thus produced is still further emphasized and rendered permanent by cell division and the formation of partition walls. I have recently found that when different substances of the egg are displaced by strong centrifuging they tend to come back to their normal positions unless prevented by partition walls which have formed in the meantime. In the early cleavage stages of many animals the cell divisions are differential both as regards the size and the substance of the daughter cells, but in such cases the cleavage is not responsible for the differentiation as is plainly shown by the fact that the segregation of the different substances occurs before division, and the inequality of the cleavage may be foreshadowed by lobes of the cytoplasm even before the nucleus

begins to divide. Lillie has shown that differentiation may proceed far in the case of *Chætopterus* in the absence of any cleavage. On the whole then, although the lines of cleavage tend to follow the pre-existing lines of differentiation the principal part played by cleavage in the process of differentiation is in rendering permanent the segregation of the different substances.

Finally we may conclude that the nucleus plays a less important rôle in the localization of different substances than in the formation of those substances. Nevertheless, in differentiation, as well as the metabolism, there is every reason to believe that the entire cell is a physiological unit. Neither the nucleus nor the cytoplasm can exist long independently of the other; differentiations are dependent upon the interaction of these two parts of the cell; the entire germ cell, and not merely the nucleus or cytoplasm, is transformed into the embryo or larva; and it therefore seems necessary to conclude that both nucleus and cytoplasm are involved in the mechanism of heredity.

V

It is well known that many biologists believe that the nuclei, and more particularly the chromosomes of the germ cells, are the exclusive seat of the inheritance material. O. Hertwig and Strasburger first formulated this hypothesis as a result of their studies on fertilization. Roux suggested that the chromatin is the most important part of the nucleus, in view of the exact manner in which it is divided in mitosis. Van Beneden and Boveri discovered that the chromosomes come in equal numbers from the egg and the sperm; that the number of chromosomes in each of the germ cells is one half the number characteristic of the species, and that by the union of these cells the characteristic number is reestablished; and finally that the maternal and paternal chromosomes are distributed with exact equality to all the cells of the developing organism. Furthermore, it was shown by Rabl and Boveri that there is a continuity (or persistent individuality) of the chromosomes from one cell cycle to the next. That the nucleus alone is the bearer of the inheritance material was affirmed by Hertwig in 1892, in view of the following facts: (1) The equivalence of the inheritance material in male and female; (2) the equal distribution of the inheritance material to all cells of the organism; (3) the prevention of the summation of the inheritance material, by its reduction before fertilization; (4) the isotropy of the protoplasm.

Since that time many additional evidences that the chromatin is the seat of the inheritance material have been brought to light, only a few of which can be summarized here. Boveri found in the development of *Ascaris* that the germ cells, which preserve all the characteristics of the species, also preserve all the chromatin of their chromosomes, but that in the body cells, which undergo differentiation, the chromosomes undergo diminution. Weismann assumed as a logical necessity that in the maturation of the egg and sperm there must occur a division of a peculiar type, a reduction division, the significance of which is the halving of the germ plasm and its contained hereditary units, in preparation for the union of egg and sperm in fertilization. Such a reduction division of the chromosomes has since been observed by many investigators in a large number of organisms. More recently Montgomery, McClung, Paulmier, Wilson and others have found chromosomes of many different sizes and shapes within the same nucleus, and Boveri has shown, by a masterful analysis, that in echinids the hereditary value of individual chromosomes is different, although here they are all alike in form.

Boveri also discovered that enucleated egg fragments of *Echinus* fertilized by sperm of *Strongylocentrotus* produced larvæ which had purely paternal characteristics. These results have, however, been called in question by Seeliger, Morgan and Driesch; but even accepting Boveri's results, this experiment does not completely demonstrate that the chromosomes are the only "bearers of the inheritance material," as we shall see later. Finally, as a fitting climax to this chapter of remarkable disclosures as to the chromosomes, may be mentioned the epoch-making discovery of McClung, Wilson and Stevens that in certain groups of insects the dimorphism of the sexes is correlated with a chromosomal dimorphism of the spermatozoa.

These are but a few of the many notable discoveries which have been made within recent years regarding the chromosomes, and while they do not demonstrate the truth of the chromosomal inheritance theory, they do prove the very great significance of the chromosomes in the process of heredity. Boveri concludes his last great work on "The Development of Dispermic Sea-urchin Eggs" with these words (p. 260):

> After all has been said, I believe that we may regard the view that specific characteristics are transmitted from the parent to the child through the chromosomes of the egg and the sperm nuclei, as a theory which has a series of facts in its favor and up to the present time not a single one against it.

VI

Against the extreme form of this theory, as held for example by Hertwig, many general and specific objections may be urged. General objections are based upon the consideration that the entire cell, cytoplasm as well as nucleus, is concerned in differentiation and that neither is capable of embryonic development in the absence of the other. Differentiation is indeed the result of the interaction of nucleus and cytoplasm, and how then can it be said that the nucleus is the only seat of the inheritance material? If held rigidly, this theory involves the assumption that the cytoplasm and all other parts of the cell are the products of the chromosomes, and that therefore the chromosome and not the cell is the ultimate independent unit of structure and function—an assumption which is contrary to fact. Furthermore, since heredity includes a series of fundamental vital processes such as assimilation, growth, division and differentiation, there is something primitive and naïve in the view that this most general process can be localized in one specific part of the cell—something which recalls the long-past doctrines that the life was located in the heart or in the blood, or the ancient attempts to find the seat of the soul in the pineal gland or in the ventricles of the brain.

Among specific objections may be mentioned the fact that the cytoplasm is not isotropic, as Hertwig supposed, but rather that many fundamental differentiations are found in the cytoplasm of the egg at the time of fertilization and immediately after. As evidences of such differentiations may be cited, (1) polarity and symmetry, (2) differential cleavages, (3) positions and proportions of important organ bases, (4) various types of egg organization, (5) experiments in hybridization.

1. So far as is known, the animal pole of the egg becomes the aboral pole of the gastrula in all animals, while the cytoplasm in this region gives rise to the ectoderm of the developing animal. This polarity of the egg may be traced back through its ovarian history to its earliest stages, and it is probable that in some cases at least it is directly continuous from generation to generation. Here then is an important character which is inherited through the cytoplasm and not through the nucleus.

2. Similarly, the symmetry of the cyto-

plasm of the egg frequently corresponds to the symmetry of the adult. In many bilateral animals the fertilized egg is bilaterally symmetrical. Such bilaterality is found even in the ovarian eggs of insects and cephalopods, while in other cases, such as ascidians and amphibians, it appears immediately after fertilization. In still other groups there is reason to believe that a bilateral organization may be present in the unsegmented egg, even when it may not be directly visible. Thus in most gasteropods there is no direct evidence of bilaterality in the unsegmented egg, but in *Neritina* Blochmann observed a group of granules on each side of the animal pole, and in later development these were found in the velar cells of the right and left sides. In all gasteropods the velum arises from similar cells of the early cleavage, and yet the bilateral groups of "Urvelargranula" have been found only in *Neritina*. Is it not probable that in other gasteropods similar bilaterally distributed substances are present, although not directly visible?

Gasteropods also show a striking correlation between the distortion of bilateral symmetry in the spirally coiled body of the adult and the symmetry of cleavage. It is well known that in certain gasteropods the body is coiled to the right, in others to the left, and corresponding to this inversion of the symmetry of the adult, Crampton found that there was an inversion of the symmetry of the cleavage. The cleavage of a half-dozen genera of sinistral gasteropods is now known and in every instance it is the reverse of that found in dextral gasteropods. Furthermore, this inversion of symmetry may be traced back to the unsegmented egg. Such a case shows conclusively that not only bilaterality is present in the cytoplasm of the egg, but that even departures from such symmetry are also present.

3. In the cleavage of the eggs of many animals it has been shown that the position, shape, size and substance of the blastomeres; the direction, time and quality of cell-division; the size of the nucleus, centrosomes and chromosomes, are all under cytoplasmic, rather than nuclear control. That the type of cleavage, its rhythm, rate and direction are determined by the cytoplasm of the egg has been shown by myself in the normal development of gasteropods, and by Boveri and Driesch in the case of echinoderm hybrids; that the size of the nucleus, centrosomes and chromosomes is dependent upon the volume of the cytoplasm is clearly shown in Crepidula, where, in the large and small blastomeres, these structures are invariably proportional in size to the volume of the cytoplasm. In the case of echinoderms, on the other hand, Boveri holds that the size of the nucleus is dependent upon the number of chromosomes which it contains, and that the size of the cell is controlled by the size of the nucleus. The latter is certainly not the case in annelids, mollusks or ascidians.

4. Another direct correspondence between the cytoplasm of the egg and the structure of the larva may be found in those animals in which particular substances of the egg become localized in definite regions and finally give rise to specific parts or organs of the embryo or larva. Such cases are known among animals belonging to a large number of phyla. Among ascidians the substances which are to enter into the formation of the ectoderm and endoderm, the muscles, mesenchyme, notochord and nervous system are present in the two-cell stage in relatively similar positions and proportions to the corresponding organs of the larva. If any of these substances is removed from the egg, the embryo which develops from such an egg lacks the corresponding organ; and conversely, if these substances are forced into abnormal positions in the egg, the

characteristic organs to which they give rise appear in these same abnormal positions. There is, therefore, in this case, both negative and positive proof that these materials of the cytoplasm of the egg are actually "organ-forming substances."

5. In different phyla there are marked differences in the localization of the ooplasmic substances, corresponding to differences in the location of the organs in the embryo or larva. Many different phyla may, therefore, be distinguished by the type of ooplasmic localization which they show. In its general features, therefore, the characteristics of the phylum are present in the cytoplasm of the egg cell.

All of these observations on the cytoplasm go to show that it is not isotropic, as Hertwig supposed, but that it is differentiated and that many of the characteristics of animals, especially such as apply to their general type of organization, are represented in the cytoplasm of the egg.

6. Finally as evidence that inheritance may take place through the cytoplasm of the egg, reference must be made to the extremely important work of Loeb and of Godlewski. By concentration of hydroxyl ions Loeb found that it was possible to cause the spermatozoa of starfishes and ophiurans to fertilize the eggs of sea urchins. The embryos and larvæ resulting from such crosses showed only the characteristics of the mother. Later Godlewski, using the same methods, was able to fertilize the eggs of a sea urchin by the sperm of a crinoid, and although such hybrids were raised to the larval stage they showed only maternal characteristics. Still more, enucleated urchin eggs fertilized by crinoid sperm produced gastrulæ of purely urchin type. These results demonstrate, as Boveri admits, that the chromosomes of the sperm do not in this case influence or modify the cytoplasm of the egg cell; while the experiments on the enucleated egg show that the characteristics of the organism, at least as late as the gastrula stage, are derived entirely from the egg cytoplasm.

Boveri long since showed that the early stages of development, perhaps as late as the blastula or gastrula, are uninfluenced by the spermatozoon and are purely maternal in type; in the case of Godlewski's hybrid larvæ he supposes that the sperm chromosomes remain permanently inactive. But however this result is to be explained, it may be considered as definitely settled that the early development of animals is of purely maternal type, and that it is only in stages later than the gastrula, and consequently after the broad outlines of development and the general type of differentiation have been established, that the influence of the spermatozoon begins to make itself felt; and it is equally certain that this type of differentiation is predetermined in the cytoplasm of the mature egg cell, rather than in the egg nucleus.

On the other hand, there is no doubt that the differentiations of the egg cytoplasm have arisen, in the main, during the ovarian history of the egg, and as a result of the interaction of nucleus and cytoplasm; but the fact remains that *at the time of fertilization the hereditary potencies of the two germ cells are not equal, all the early development, including the polarity, symmetry, type of cleavage, and the relative positions and proportions of future organs being predetermined in the cytoplasm of the egg cell, while only the differentiations of later development are influenced by the sperm. In short, the egg cytoplasm fixes the type of development and the sperm and egg nuclei supply only the details.*

This conclusion is not a refutation of the nuclear inheritance theory, but it is a profound modification of it. At once it destroys the argument that since there is equality of inheritance from both parents there must be equivalence of inheritance

material in egg and sperm. So far as those characteristics are concerned which appear late in development, it is highly probable that there is equality of inheritance from both parents, but in the early and main features of development, hereditary traits, as well as material substance, are derived chiefly from the mother.

Finally I may call attention briefly to the bearing of these conclusions on the mechanism of evolution. I have elsewhere (SCIENCE, No. 536) discussed the proposition that the evolution of organisms must take place through the evolution of their germ cells, and that relatively slight modifications in the localization of the formative substances of the egg may produce profound modifications in the adult.

One of the principal difficulties in explaining, on evolutionary grounds, the origin of different phyla has been the dissimilar locations of corresponding organs or parts. These difficulties are well illustrated by the theories which attempt to derive the vertebrates from the annelids or from any other invertebrate type. If evolution takes place through the transformation of the egg cell rather than of the adult, it is no more difficult to explain the different locations of corresponding parts in these phyla than their different qualities. Changes in the relative positions of parts which would be absolutely impossible in the adult may be readily accomplished in the unsegmented egg, as is shown by cases of inverse symmetry.

In the light of the conclusion that only the later and more detailed differentiations are influenced by the sperm, it follows that experimental work which aims to modify the fundamental features of an organism must be directed to the ovarian egg rather than to the sperm, or to the developing embryo.

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THE INFLUENCE OF FRICTION IN ECONOMICS[1]

THERE has always prevailed, since the foundation of systematic political economy, a conflict between men of theory and men of action. Men engaged in practical business affairs and even in great financial operations have refused again and again to accept the abstract conclusions drawn from so-called economic laws, and have insisted that the rule of practical common sense, if based upon a careful observation of facts, was a safer guide than economic theory. In the field of tariff legislation this divergence of opinion has perhaps been more marked than in the field of finance. This difference, so far as it exists, tends to support the view which is here laid down—that the economist has erred in a measure in seeking to apply abstract principles too rigidly to actual conditions by failing to take account of friction in the application of these principles.

The economist, working out the theory of the conduct of the economic man according to the principles of enlightened self-interest, finds in them a harmony and a rule of law which in his mind give them something of the beauty and precision of the movement of the spheres. He is impatient of qualifications which detract from the simple and direct operation of the principles derived from these theories. The principles of the flow of capital to the market where the price paid for its use is the highest, of changes in prices according to changes in the quantity of money, of the evolution of production and manufactures in such a manner that each community and each individual shall find his most profitable work under the regime of free competition, are principles so simple to his mind that he can not understand how they can be disputed.

Nor could such principles be long disputed, if the current of trade flowed as freely as the waters of the ocean into a vacuum wherever scarcity indicated a given demand, and if money and capital

[1] Address of the vice-president and chairman of Section I—Economics and Social Science—American Association for the Advancement of Science, Chicago meeting, 1907–8.

moved without restraint to the market where they found the most profitable use. If every one bought in the cheapest and sold in the dearest market, then universal free trade might prevail among the nations, imperialism would fold its flag and sheathe its sword, and every community would be producing either the agricultural products or manufactured goods which experience had taught that it could produce with the greatest efficiency and in exchange for which it could obtain the greatest sum of the desirable products of other communities.

But we know that this is not the case. No peace conference and no appeal to the universal brotherhood of man can prevent wars based upon the intensity of industrial competition. The world of to-day is organized upon the system of competing nationalities. Many generations distant is the dream of universal peace among the nations, such as Rome by her power enforced for four centuries throughout nearly the entire civilized world from the time of Augustus to that of the third Valentinian. The origin of modern wars, as was doubtless the case in reality with many ancient and medieval wars, is the struggle for existence. Few nations have yet been willing to stand forth, as does Great Britain in the field of trade, seeking no shelter behind artificial barriers against the competition of other peoples. The cause of free trade, which it was believed in Cobden's time had only to be presented to civilized men, like the teachings of the gospel, in their simple beauty, to make converts of all the world, has made little visible progress in recent years. On the contrary, a great wave of protectionism swept over Europe in the eighties and the barriers have been erected higher in most cases rather than lower within our generation. Converts to the principles of Adam Smith and John Stuart Mill and Cobden have undoubtedly been made among thinking men, but even those men, when exalted to official place, have usually found that they had to deal with a *status quo* which was too enormously complicated to permit the cutting of the Gordian knot of special privilege and interdependent industries during the time in which they were likely to continue as public servants.

More significant still of the general belief of responsible governments, that universal free trade and the unfettered movement of capital are still far in the future, has been the policy of imperialism which has followed on the heels of protection and been deemed sufficiently important to justify the sacrifice of thousands of lives and millions of treasure, even by that champion of economic freedom, the empire of Great Britain. Experience has shown that "trade follows the flag" to a large extent, not perhaps because competition in a free field would not make the flag a negligible factor, but because by skilful regulations and legislation can be created discriminations and favors of many sorts which give potent advantages to those under the flag over alien rivals. Even the policy of "the open door" in the East, which did honor to the memory of Secretary Hay as much as it did violence to the professed economic views of some of his predecessors, was not potent enough to insure that equality of opportunity for non-Russians in Manchuria which it was designed to secure and did not prevent the greatest death-struggle of our generation between Russia and Japan as to who should in future attend to the execution of this avowed policy of equality.

If the professor of political economy, therefore, desires to exercise a greater influence than he exercises to-day in molding the policy of this nation or any other, he may well give greater weight than heretofore to the influence of friction in econ-

omics instead of reposing upon the comfortable assumption that economic forces operate in a vacuum. Experience demonstrates that even the movement of capital is not without friction. If friction did not exist, the interest rate for loans upon equally secure collateral would be the same in New York as in London, in St. Petersburg as in Paris, in Arkansas as in Chicago. Wherever good opportunities for loans arose, money would flow like water into the vacuum of demand. The merchant of Little Rock, other things being equal, would obtain his borrowed capital at the same rate as the mercer of London or the jeweler of the Rue de la Paix. But the merest tyro in finance knows that this is not the case. Not only has the creation of physical means of communication been necessary to bring markets together, but the creation of the means of exchange has also been necessary. And so far as markets have been brought together, it is largely by state-created, but not state-operated, institutions. How could the market of Paris draw to itself the savings of France for investment in the securities of the world and maintain the lowest and most uniform discount rate of any great market but for the giant mechanism which Napoleon created, under the guidance of Mollien, under the name of the Bank of France? How could Canada enjoy comparative uniformity of interest rates in all her provinces but for the Canadian banking law, which confers upon institutions of limited liability the privilege of issuing circulating notes and establishing branches in every part of the Dominion? As Bagehot truthfully declared of the conditions under which capital is transferred, "You can not have it unless you have a strong government, which will keep peace in the delicate line on which people are moving." And again he sets forth, as indicating the narrow limits within which the law of the transfer of capital operates even in modern society:

> But though the loan fund begins so early in civilization, and is prized so soon, it grows very slowly; the full development—modern banking such as we are familiar with in England—stops where the English language ceases to be spoken.

And if there are fetters upon the free movement of capital, how much greater are those upon the free movement of labor! It is a favorite argument, and a sound one, of even the most orthodox of economists, that the effect of a depreciating currency is felt in the rise of prices before it results in the rise of wages. The friction which attends the lifting of the wage scale is forged into a powerful argument in favor of giving steadiness to the unit of value. Why then is not the effect of this friction worthy of consideration when it affects rates of customs duties and other national economic policies? I do not say that this argument is not often abused, but I do say that the classical economist is not justified in appealing to its finality in the one case and treating it as beneath contempt in the other.

The abstract principle of wages is that, other things being equal, similar service should command the same equivalent in every part of the world. But one finds skilful carpenters in Manila working for about fifty cents a day in gold, and in America at two dollars and fifty cents. In Hong Kong in 1901 I was told that good Chinese brick-layers were working for forty cents a day in silver or about twenty cents in gold. Why did they not strike for the same wages as their fellow-workmen in London or New York, or San Francisco? Because, behind them, in the interior of China, were millions upon millions of their fellow-countrymen, as ready to take their places in the ranks of cheap workers as the loyal Japanese soldiers and

sailors who were ready to climb over the bodies of their dead comrades to victory before the walls of Vladivostock or on the smoking decks of their battleships in the China Sea. Would it be of any use to preach to the Chinese mechanic in Hong Kong the doctrine of the eventual equalization of wages by the movement of masses of laborers from poorly-paid markets to those well paid until wages in Hong Kong rose to the level of those in London? Would he not reply that an equalization which could not be accomplished in perhaps three generations was too remote to justify his hazarding his job?

The operation of the quantity theory of money is another field in which economists themselves have been compelled by the exigencies of their own arguments to admit the influence of friction upon the working out of theory. Whatever may be thought of the principles laid down when the use of money was not so extensively supplemented as at present by instruments of credit, it is now obvious that those principles rarely operate in a vacuum. Other influences, so important that they often outweigh changes in the quantity of the metallic monetary stock, come constantly into operation. The argument of a few extremists in the silver campaign, that "money of ultimate redemption," or "basic money," alone influences prices, would hardly be defended to-day even by the followers of Mill. Those, on the other hand, who depart farthest, either from his theories or from their practical application, contend that prices are influenced by the volume of banking credits, by the rate of discount, and preeminently by the demand and supply for particular articles which interacts in one case upon demand and supply for other articles, so that there is never reached a static point at which a proportionate increase in the quantity of money is accompanied by a like and uniform increase along the entire line of manufactured and exported goods.

The friction which takes place in the introduction of a new stock of gold from the mines into general circulation has been made the subject of elaborate studies by Cairnes, Chevalier and many others. Their arguments are often quoted in support of the contention that out of this friction emerges ultimately a definite relation between prices and the quantity of money. But if this friction occurs in this first flow of the new metal from the mines, then it almost inevitably follows that it occurs also in its later movements between communities and even in its relation to different articles. The supply of any article may be so uniform that it is inadequate under certain conditions of demand and excessive under new conditions of demand. Hence come about relations of supply to demand which affect such articles differently from those whose supply can be promptly curtailed or promptly expanded according to the conditions of the market. Friction operating with different degrees of intensity in the case of different articles thus makes it practically impossible that at any given moment such friction shall have been overcome in equal degree for all commodities and that they shall show a uniform increase or decrease in price based upon a corresponding change in the quantity of money. Of this friction intelligent economists now generally take note, even where they adhere to the theory that in the end prices become adjusted to an increase or decrease in the stock of the standard metal.

If the influence of friction, then, can be admitted in respect to the movement of capital, the tendency of wages, and changes in the quantity of money, is it not illogical to insist too strongly that it should not be recognized in systems of taxation and especially in rates of customs duties? The

contention that "the foreigner pays the tax," made by the extreme protectionists in framing the McKinley and Dingley laws, may find verification in specific instances, where the foreigner would prefer to hold a market already acquired, even at a lower rate of profit, rather than to sacrifice a plant built entirely or chiefly for supplying that market. Cases of this kind do not, of course, justify the attempt by political legerdemain to impose upon other nations the fiscal charges of the state. Indeed, to the enlightened cosmopolitan they appear a rather undignified and pitiful device to rob somebody else to obtain one's daily bread. But the fact can hardly be disputed that the operation of those simple economic harmonies which were the dream of Mill and Bastiat and Cobden is essentially hampered by the inability of capital and labor to move instantly from one place to another or from one employment to another.

A nation which has built up even an artificial system can not perhaps afford to throw down the structure at a blow. It may be demonstrable that the sooner it is destroyed the more fully will come into operation the principle that labor finds its most efficient employment under the system of free competition. But if the existing capital of the nation is invested, as in the case of the United States, in manufacturing establishments to the extent of thousands of millions of dollars, too great a sacrifice may be involved in abandoning enterprises suddenly, even where the capital invested in them was misapplied. Hence practical statesmen, whatever their theoretical views, have in but few cases proposed the sweeping abolition of protective tariff laws. Changes which will afford free raw materials to manufacturers, and will reduce excessive profits and unnecessary exactions upon the customer, can undoubtedly be made with wisdom in this and most other protective countries. The appeal to throw down the structure, however, must almost inevitably be treated by practical statesmen, like the quantity theory of money and the theory of the free movement of capital, as representing what might be desirable if economic forces operated in a vacuum, but what is rarely, if ever, attainable in the world of practical affairs.

The science of political economy can afford to recognize these limitations upon its application to practical affairs, without yielding that devotion to abstract truth which gives charm to the work of its greatest exemplars. If there have been conflicts in the past between men of theory and men of action, they have been largely due to this failure to recognize the restrictions imposed by actual conditions, the disposition to insist that a fundamental truth once demonstrated should be accepted by all men, without regard to limitations of time and space, just as the great teachers of Christianity have sometimes urged that the existing social order should be forsaken and that Christ's mandate should be put in immediate force, to sell all that one hath and give to the poor. The practical theologian knows as well—perhaps better—than the political economist, that these principles are not of immediate application in their extreme form and that if the world can be guided steadily towards those heights where truth lies, it will make more rapid progress than by preaching the impracticable in a world of practical men and practical affairs. It is the duty of the political economist to continue to preach these fundamental truths which have been worked out by the masters of the science within the past two centuries, but this need not lead him to reject and spit upon the practical considerations which the statesman has to face in applying abstract principles to mundane conditions.

It should not be forgotten that economic science differs in essential respects from the physical sciences. In those sciences we find forces which work according to fixed laws. Even in them we find the effect of those laws mitigated or offset by friction and opposing forces. In the world of economic science we do not deal with conditions so unvarying. The so-called laws of economic science are simply the interpretation of what is likely to be the action of men under the stimulus of self-interest in the field of free competition for the acquisition of goods and the accumulation of capital. But while two streams of water act in exactly the same way under similar physical laws, no two men act in precisely the same way under the operation of mental laws. At least, if laws exist which compel such uniformity of mental action, they are too abstruse to have yet been discovered and formulated.

From the standpoint of existing conditions, therefore the psychological element is an important factor in mitigating the operation of so-called economic law. To acquire commodities and save capital is not man's sole impulse. On the contrary, in the midst of the most highly developed civilized society to-day, a large percentage of men are influenced by other motives than the desire to achieve the greatest result by the utmost exertion of their labor. Some prefer idleness to labor; others prefer spending to saving; others pursue ambitions which have their roots only remotely in the acquisition of money. And if this is so in civilized communities, how much more is it so in those where commerce is feebly developed, where the church or the state, or immemorial custom prescribe the routine of each man's life, and where competition in our modern American sense is almost a thing unborn.

Economic law does not operate in a vacuum or in anything approaching a vacuum even in the most advanced modern society. It gropes blindly in a mist of disturbing forces, and with many digressions from its true objective, even where its operation is most nearly unhampered. The political economist, therefore, can afford to admit that the man of practical affairs sees in some respects as clearly as himself regarding existing requirements, even though his eyes are fastened upon the ground while his own are uplifted to the stars.

Charles A. Conant

SCIENTIFIC BOOKS

Ice Formation, with Special Reference to Anchor-Ice and Frazil. By Howard T. Barnes, M.A., D.Sc., F.R.S.C. New York, John Wiley and Sons. 1906. Pp. 260.

To persons living in moderate climates, the statement of Dr. Barnes, in his introduction, is very striking that where surface ice is prevented from being formed "as in a rapidly flowing river we meet with the worst effects from the presence of ice"; notwithstanding the fact that the temperature of the water never varies more than a few thousandths of a degree from its freezing point, even when the air is 30° or 40° lower. The account which Mr. Barnes gives of the difficulties which the ice causes in the St. Lawrence River at Montreal entirely substantiates the statement. There are three kinds of ice which are met with; the surface ice, the anchor-ice, which is formed in the bed of the river and the frazil, which is formed as small individual crystals at the surface of the swiftly flowing water. The frazil is formed in the rapids and is carried under the surface ice in the quiet water below and adheres to its under surface. Thus the ice becomes thick enough to choke up the channel of the river and cause a serious flood. Frazil also interferes with the water power used at Montreal by choking up the machinery, and a commission has existed for some time for the purpose of studying the condition leading to the formation of frazil and the best methods of preventing the damage done by it. This commission had made many determinations of the temperature of the

water with mercury thermometers and had failed to discover any real variations from the freezing point, but the Callendar platinum resistance thermometer makes it possible to determine the variation of the temperature easily to a thousandth of a degree centigrade, and Dr. Barnes's familiarity with this instrument enabled him to make extremely accurate observations showing the condition existing when frazil and anchor-ice are formed.

The first few chapters of the book are devoted to a compilation of the laws of the transfer of heat, the various methods of determining the different constants of ice and water, and the general structure of ice. In referring to the various workers in these fields, Dr. Barnes gives their names and the year of their work but does not give references to their original publications, which would be very useful for students of the subject. The platinum resistance thermometer is then described and the degree of accuracy obtainable with it is shown to be in the neighborhood of 1/10,000 of a degree centigrade, under good laboratory conditions; these were not obtainable at the river bank where Dr. Barnes made his observations, but he considers that the water temperatures which he determined are accurate to a thousandth of a degree. The rest of the book is devoted almost entirely to the study of anchor ice and frazil, and their occurrence in the St. Lawrence River.

Many observations and opinions regarding the formation of anchor ice are cited and Dr. Barnes wisely makes a long extract from two papers by the Rev. Dr. Farquharson, in the *Philosophical Transactions* for 1835 and 1841. His observations were made on the rivers Don and Leochal in Aberdeenshire, and they were so well made that one is entirely convinced that he is right in ascribing the formation of anchor-ice to the cooling of the bottom of the streams by radiation. The absorption of water for radiation of long wave-lengths is not well known but Dr. Barnes made a preliminary experiment to show that bodies at low temperatures can radiate through water and glass; a coil of platinum wire covered with a layer of water between glass, was exposed to radiation on a clear night; the coil became cooler by radiation.

Careful observations made near Montreal show that anchor-ice is not formed except on cold clear nights and in situations permitting free radiations into space. Anything interfering with this radiation, such as a bridge or a clouded sky, will entirely prevent the formation of anchor-ice, and a very short period of bright sunshine is sufficient to loosen the ice from the bottom and cause it to rise, sometimes in great quantities, to the surface.

Frazil, on the other hand, is formed at the surface, where the water is so disturbed by currents or strong wind as to prevent the formation of a surface sheet. All that is necessary for the formation of this kind of ice is very low temperature and rough water. The water becomes undercooled to a few thousandths of a degree and small crystals of ice are formed and carried down with the current. Bright sunshine is sufficient to prevent the formation of frazil; and the experiment of Dr. Barnes shows how quickly the undercooled water is brought up to the freezing point when the sun shines upon it. His experiments were carried out in a small hut on the shore of the river. It is necessary in these experiments to have as a basis for comparison a mixture of snow and water exactly at the freezing temperature; some difficulty is found in obtaining this to the degree of accuracy required. Dr. Barnes found that when the water was freezing the temperature of the mixture was slightly lower than the freezing point; on the other hand, when the ice was melting the temperature was slightly higher, and he found that the variations from the freezing point depended upon the relative proportions of ice and water in the mixtures. This led him to the suggestion that "a freezing point mixture must be defined as an intimate and equal mixture of ice and water, neither gaining nor losing heat."

The final chapter in the book tells of the difficulties attending the use of water-power machinery at Montreal on account of the formation of frazil ice, and the way these have been met. One very simple method, which has served pretty well, is to take the water from

a quiet part of the river which freezes over entirely in cold weather rather than from a point on or below the rapids where frazil is formed in great quantities.

The most important parts of the book are those dealing with the formation of anchor-ice and frazil, and Dr. Barnes's temperature observations. The small section on glacier motion is hardly in accord with the present ideas of glacialists.

To any one interested in the engineering problems brought about by ice, or in the general phenomena of ice formation this book will be extremely interesting and useful.

Harry Fielding Reid
Johns Hopkins University,
Baltimore

The Chemistry of Commerce, A Simple Interpretation of some new Chemistry in its Relation to Modern Industry. By Robert Kennedy Duncan. New York and London, Harper and Brothers. 1907.

This is a book intended by its author "to interpret into simple terms and for educated lay-folk some new science in its relation to modern industry." The author seems to have realized the difficulty involved in this problem which he had planned for himself or which had been submitted to him by others. Whether the "one object of the book" indicated in the opening sentence of the introductory chapter, "to convince the manufacturer, through instances taken here and there, how absolutely applicable is modern science, to the economy and progress of manufacturing operations" will have been attained through it remains to be seen. Certainly it is not easy to make a manufacturer, prosperous in spite of his wastes, realize the importance of the economies which may be discovered and applied through the aid of thoroughly educated men, and lead him to the practical application of such economies. Adversity and active competition are the influences which are most effective in bringing about such policy, wise, at all times, and it is exceedingly doubtful if it can be brought about by even the most attractive presentation of generalities—carefully prepared balance sheets are far more interesting and intelligible to the manufacturers of this country at least; and while the author has made a most interesting and readable book, it will, we fear, be read with closer attention and appreciation by those lay-readers who least need it, in view of the object of its preparation. In twelve chapters the following subjects have been treated: Catalysis, Fixation of Nitrogen, Rare earths and their uses, High Temperatures and Modern Industry, Modern Chemistry and Glass-making, Industrial Alcohol, Floral Perfumes, Making of Medicines, Microbe Inoculation, Cellulose, Industrial Fellowship. Each subject furnishes the author with illustrations of the importance of the application of scientific methods and the truths they develop, in industrial work. Manufacturers who are inclined or are desirous to proceed in rational ways to attain the best results in quantity and quality of product and in cost of operation, must certainly be attracted by what the author has presented. But those who most need the book will not, we fear, read it; while those who will read it need it least. Yet those of us who know the full truth of all that is presented in the book will at least hope that it may be widely read and that the suggestions it offers may find extended application not only for the good of manufacturers, but for the world at large. The book then is generally acceptable, but it may be criticized by some readers on account of the statement to be found on page 177. "But this was in the days long ago . . . when experimental medicine was carried on by physicians like Paracelsus, who stood by the bedside of his patient, watch in hand," etc. Many readers will remember that the first watch was made one hundred years or more after the death of Paracelsus. Such pleasantries seem out of place in such a book and the technical description of the analytical method for standardizing drugs involving "dissolving out with chloroform and ultimately titrating them with sulphuric acid" will scarcely attract the lay-reader. The use of the word "dubiety," when the more familiar "doubt" would serve, may unfavorably affect some of the lay-readers the book is specially intended to influence favorably.

Furthermore, the statements regarding the cost of manufacture of industrial products, such as alcohol, unless they have been scrutinized and confirmed by experienced manufacturers, must be accepted with reserve and may also have some tendency to defeat the object of the book. WM. MCMURTRIE

Synopsis of Mineral Characters. By RALPH W. RICHARDS. New York, John Wiley & Sons; London, Chapman & Hall, Ltd. 1907.

This is an alphabetically arranged list of minerals and their chief physical characteristics, with concise definitions and descriptions; the chemical composition expressed by an empirical formula. Simple blowpipe reactions are also given. The book is intended as a reference work for those who have studied mineralogy and need notes to aid in the identification of minerals in the field. It is a compact 12mo of 100 pages, which may be carried about in the pocket conveniently, and will undoubtedly prove very useful to students and field workers. J. P. IDDINGS

SOCIETIES AND ACADEMIES

THE FORTIETH ANNUAL MEETING OF THE KANSAS ACADEMY OF SCIENCE

AT the meeting of the Kansas Academy of Science held in Emporia on November 29 and 30, among the many important papers read the following may be mentioned:

"Natural Gas obtained from Trees," by F. W. Bushong and D. F. McFarland. This paper gives an analysis of natural gas obtained by boring into cottonwood trees. The authors showed that this gas contained 7.21 per cent. of carbon dioxide and about 61 per cent. of marsh gas, and 30 per cent. of nitrogen. L. E. Sayre discussed the percentage of extractives in certain drugs and spices, and commented on the necessity of having improved and reliable methods for making these determinations. He also mentioned some "fake" medical preparations that were upon the market, and referred to the work of the board of health in trying to reform the fraudulent methods of labeling. Considerable attention was paid to the progress of the water survey of Kansas in papers read upon the chemical work by E. H. S. Bailey and F. W. Bushong, on the bacteriological work by M. A. Barber and W. J. Starin, on the field work by H. N. Parker, and upon engineering problems by W. C. Hoad. C. F. Menninger read a paper on "Gastric Ferments," showing the remarkable advancement in the knowledge of this subject that has recently been made. F. B. Dains and E. W. Brown reported on the reaction of formanidines, giving an account of some newly discovered bodies. Some new finds in the Kansas Chalk beds were reported by Chas. H. Sternberg. A fossil tooth and other bones from Phillips County was discussed by J. T. Lovewell. A very practical paper on the "Food Habits of the Blue Jay" was read by L. L. Dyche. In this he showed the murderous intent of this bird, not only from observation, but also from numerous dissections of the blue jay, in which the heart and other vital parts of birds were found in the crop. Grace R. Meeker discussed a curious "Impatiens" recently found. W. Knaus, besides reporting on additions to Kansas coleoptera, mentioned some new coleoptera found in New Mexico, and many interesting species collected at night in McPherson, Kansas. "A Parasite on Eggs of Mantis" was the subject of a paper by Mrs. L. C. R. Smyth. L. C. Wooster read a paper on the "Antiquity of Man's Body-building Instincts." B. R. Rogers in a paper upon "Tuberculosis" emphasized the importance of greater precautions to prevent the spread of this disease. "The Abnormal Character of Man" was the title of a paper by J. M. McWharf. W. F. Hoyt in an entertaining way gave a report on some scientific frauds and fallacies. The "Buried City of the Panhandle" was the subject of a paper by F. L. Eyerly. B. B. Smyth discussed harmonics and magic hexagons. The advantage of fireless cooking was explained by J. T. Lovewell. H. P. Cady gave a résumé of his work on the occurrence of neon in natural gas, and showed that it was possible to obtain neon in appreciable quantities from this source. Papers on the "Quantity of Water found in Oysters" as they are marketed, and the "Occurrence of Copper in Oysters," were pre-

sented by J. T. Willard. A description of a fossil tusk found in Equus beds was given by E. O. Dare. The nomenclature of the carboniferous, showing the most recent classification as adopted by the Kansas Geological Survey, was discussed by E. Haworth and J. Bennett. The use of a score-card for the comparison of natural waters with the use of a different rating for surface waters, deep wells and shallow wells was discussed by E. H. S. Bailey. "Some Preliminary Studies on the Moon" was the subject of a paper by F. A. Marlatt.

The retiring president, J. A. Yates, gave the presidential address on the "Value of the Work of the Scientist to Humanity."

E. H. S. Bailey

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 640th meeting was held on December 7, 1907, Vice-president Bauer in the chair. In accordance with the by-laws of the society, the evening was devoted to hearing the president's address, which was delivered by Mr. John F. Hayford, on "The Earth, a Failing Structure."

The full text of this address will soon appear in Volume XV. of the *Bulletin of the Philosophical Society of Washington.*

The 37th annual meeting of the society was held on December 21, 1907, and was devoted to the presentation of the usual annual reports and the election of officers.

The following officers were duly elected for the ensuing year:

President—L. A. Bauer.

Vice-Presidents—A. L. Day, E. B. Rosa, C. K. Wead and C. G. Abbot.

Treasurer—B. R. Green.

Secretaries—G. K. Burgess, R. L. Faris.

General Committee—C. Adler, L. J. Briggs, E. Buckingham, W. A. DeCaindry, W. S. Eichelberger, E. G. Fischer, L. A. Fischer, R. A. Harris and P. G. Nutting.

R. L. Faris,
Secretary

DISCUSSION AND CORRESPONDENCE

THE NOBEL PRIZES

To the Editor of Science: Incorrect statements about the Nobel prizes and the supposed misappropriation of certain parts of the Nobel funds crop up every year as regularly as the question of the awarding of the prizes. These discussions began several years ago both in scientific journals and in the daily press, especially in America. There seems to be an impression that American scientists and authors are being neglected by the institutions which are distributing the awards. Such an opinion was expressed, for instance, on page 50, Vol. XVI., of the *National Geographic Magazine.* It was stated in regard to the fact that up to that time (January, 1905) no American had received a prize, that "the reason is not lack of appreciation abroad of what we are doing in this country, but the neglect of Americans to apply for the prizes." This sentence was frequently quoted by daily papers, which ruminated the same old question, using in yellow-journal style the most vituperative language against the Scandinavian institutions which have to do with the awarding of the prizes. But the papers referred to omitted what is mentioned in the editorial note in the *National Geographic Magazine.* It is there said, "In the awarding of prizes only those persons are considered who are formally nominated as candidates by some institution, college or scientific society of rank and character."

The Nobel prizes are not applied for, and those having the nominating power are not confined chiefly to Swedes, as is claimed in an article in the January, 1907, number of *The Popular Science Monthly* (pp. 91–92). The statutes concerning the distribution of prizes give the right to nominate a candidate for the literary prize competition to "Members of the Swedish Academy and of the Academies in France and Spain, which are similar to it in constitution and purpose; members also of the humanistic classes of other academies and of those humanistic institutions and societies that are on the same footing as academies; and teachers of esthetics, literature and history at university colleges." This certainly gives the nominating power to others than Swedes, and probably America has the lion's share of persons with power to nominate candidates. The Swedish Academy has eighteen members, and

there are two or three other institutions in Sweden which "are on the same footing" as the academy, while the professors of literature, history and esthetics at Swedish universities do not number more than a dozen.

The nominating power for the medical prize lies with members of the medical faculties at the Caroline Medical Institute, Upsala and Lund universities in Sweden, Christiania University in Norway, Copenhagen University in Denmark, and Helsingfors in Finland, while members of at least six other medical faculties "selected in the way most appropriate of the just representation of the various countries," and in addition any number of scientists whom the staff of the Caroline Institute may see fit to select, are empowered to nominate candidates. It does not seem that the charge of the writer in *The Popular Science Monthly* is just. In regard to the scientific prizes the right to nominate candidates belongs to "home and foreign members of the Royal Academy of Science in Stockholm, members of the Nobel Committees of the physical and chemical sections of the Nobel foundation, scientists who have received a Nobel prize, professors of physics and chemistry at the universities above referred to, as well as at the Royal Technical College in Stockholm, and professors of the same sciences at at least six other universities, as well as other scientists to be selected by the Academy of Science of Stockholm. Also in this case by far the smaller number of persons with right to nominate are Swedes.

The article in *The Popular Science Monthly* referred to also says that as Nobel's "large fortune was made in Great Britain by the discovery and manufacture of dynamite, it seems likely that the instructions of his will would have been more adequately carried out if their execution had been entrusted to the Royal Society and the British courts." Of all the charges made in regard to the Nobel prizes this is certainly one of the most extravagant. Nobel's will directs that "the prizes for physics and chemistry shall be awarded by the Swedish Academy of Science in Stockholm; the one for physiology or medicine by the Caroline Medical Institute in Stockholm; the prize for literature by the academy in Stockholm (Svenska Akademien), and that for peace by a committee of five persons to be elected by the Norwegian Storting." It is difficult to see the reason why the Royal Society or the British courts should have been entrusted with the execution of the will, which particularly mentions the institutions in whose power the distribution of the prizes is placed.

That the instructions of the will "would have been more adequately carried out" by the Royal Society is a statement which, I am sure, no fellow of that august institution would ever claim.

The writer in *The Popular Science Monthly* further says that "it is truly sad and discouraging that there should be lack of good faith in the administration of a fund intended, as the testator states, 'to benefit mankind.'" His further charge that "the prizes have so far been awarded annually, but it is to be feared that when the money is needed in Sweden, it will be kept there," is as slanderous as it is undignified.

In an editorial in the same journal (Vol. 58, pp. 107–108) for November, 1900, it is also stated that

> Nobel's intentions have not been exactly carried out; the chief deviations being that part of the money is used for the establishment of certain Nobel institutes, the objects of which are not exactly defined. . . . Any attempt to divert the funds to the encouragement of the local institutions or to the education of inferior men should be carefully guarded against. Nobel's will explicitly ordered that the money be awarded in prizes for eminence and without any consideration of nationality.

If the writers of these articles referred to and all those others who appoint themselves judges in regard to this question had taken the trouble to inquire about the actual cause of the apparent "violations" of Nobel's will, they would have found that the executors of the will appointed by the testator were men who knew him intimately, and subsequently acted in full accordance with the wishes expressed by the testator during his lifetime.

Nobel was a patriot as good as any one, and although his main object was in the interest of mankind generally, his second thought was

his own country, and it is well known that he left the distribution of the prizes with certain Swedish institutions for the express purpose of putting Sweden in closer contact with the great scientific, literary and peace movements of the rest of the world.

As for the right of the executors to change the stipulations of the will there are several points to be taken into consideration. The will was very general in its wording, and all who have had to execute a general order of any kind know that when coming down to the details the exact directions given often have to be somewhat modified. In this special case there are many instances where the actual provisions of the will are not only difficult, but impossible to carry out. The testator directed that prizes be awarded to "those persons who shall have contributed most materially to benefit mankind during the year immediately preceding." This may seem very easy to accomplish, but as a matter of fact, very few discoveries of any importance have been immediately acknowledged. Let us say that an investigator within the province of medicine makes a discovery this year, which he himself and probably some of his friends would recognize as a valuable and epoch-making discovery of the greatest "benefit to mankind." But it is not very likely that the medical world in general would immediately accept the discovery as correct or acknowledge its superiority above anything else done the same year. This would not be in accordance with the scientific spirit to investigate thoroughly before accepting a statement as truth. Nor could it be expected that any scientific body in the world could be ready to immediately pronounce this discovery as the greatest accomplishment during the year. In no single case where Nobel prizes have been awarded has the work on which the award was based been recognized as a great work during the same year. All those critics who are so ready to offer their advice in regard to the execution of Nobel's will apparently do not realize that the exact words of the will are impossible to follow literally in practise. It is most difficult to fix the exact date for an important discovery. Moreover, the author may not be able to publish and prove his discovery within a year's time, and if the provisions of the will were to be taken literally, a discovery made in 1905 but published in 1907 would be disqualified for competition in 1909, the year in which it was ascertained that the discovery was really of great "benefit to mankind." Such an interpretation would be ridiculous, but it is really what many of the critics claim as the only right one.

In the execution of Nobel's last will it has also been found necessary to provide that:

> If it be deemed that not one of the works under examination attains to the standard of excellence required, the sum allotted for the prize or prizes shall be withheld until the ensuing year. Should it even then be found impossible, on the same grounds, to make any award, the amount in question shall be added to the main fund, unless three fourths of those engaged in making the award determine that it shall be set aside to form a special fund for that one of the five sections, as defined by the will, for which the amount was originally intended. The proceeds of any and every such fund may be employed, subject to the approval of the adjudicators, to promote the objects which the testator ultimately had in view in making his bequest, in other ways than by means of prizes.

This is often objected to as "illegal," "in direct violation of the provisions of the will," etc. Any one who cares to reflect over the proviso in the will that the prizes be given annually will find that this latter may not always be possible. In the constant stream of literature appearing each year it may be found that no work can be singled out for its excellence or considered worth a prize of about $40,000. What would these practical, well-meaning critics do in such a case? Award at all events. It is very doubtful if such a course would be to the "benefit of mankind" or in accordance with the general tendency of the testator's will.

Professor Svante Arrhenius, of Stockholm, wrote me in regard to this question, a letter dated May 28, 1905, and I give here a translation of some extracts:

> It can hardly be said that any violation of Nobel's will has been committed. The will is so briefly worded, that it could hardly serve as a

foundation for the distribution of the prizes without explanatory additions. On account of the Utopian form of the will some of Nobel's heirs commenced a lawsuit against the institutions which Nobel had appointed as distributors of the prizes. Rather than lose a part of the funds in a lawsuit, which could be prolonged for an uncertain length of time, the said institutions decided to compromise with the heirs, and to interpret the will by the statutes which were drawn up by a committee, in which the said institutions and the heirs were represented, and which statutes were later approved by the government. All these parties were interested in reaching as far as possible the aims which Dr. Nobel had intended by his will. In this regard the committee in question naturally had much better knowledge of the facts than the testator.

It was then acknowledged that it was impossible to award the prize "to the person who shall have contributed most materially to benefit mankind during the year immediately preceding." The great inventions, especially the theoretical ones, are generally not of such a nature that their value is acknowledged immediately after their publication. It was therefore decided to change "preceding year" to "late times." I can not see that this is a "violation" of the idea of the will. I also think I can say that the authorities who have the execution of the will in their hands have exercised great care not to award prizes for discoveries which have been made a very long time ago, although many proposals to this effect have been presented. The said institutions further agreed that one tenth of the proceeds should annually be added to the main fund in order to prevent a decrease in the amount of the prizes on account of any future lowering of the money value or the rate of interest. Finally these institutions considered that the amounts, which could be set apart for defraying of expenses connected with the judging of the proposals submitted, should primarily be used for the establishment of Nobel Institutes, the purpose of which is to promote in other ways the aims of the will. By this arrangement the prizes have decreased (by 25 per cent.), but I have not yet heard any prize winner criticize this. Whether the recipient of a prize receives $40,000, as is now the case, or $52,000 is rather unimportant. The indirect result of the prizes is the greatest. It may also be pointed out that the distributors of the prizes have shown great impartiality in following the testators wishes, that Scandinavians should not have any preference before others. . . . This fall (1905) a Nobel Institute in physical chemistry is to be established. The annual expenditure for this (including rents, etc.) is only $4,400. I have been elected chief of this institute, and I expect to be able to promote the aims of the will more in this capacity than on account of the fact that I shall have received a Nobel prize.

As Professor Arrhenius says, an adjustment of interests was amicably entered into to prevent the possible loss of a considerable amount of the funds by a long lawsuit, and in the deed of adjustment it was affirmed and declared by the testator's heirs, that:

By these presents we do acknowledge and accept Dr. Nobel's Will, and entirely and under all circumstances relinquish every claim for ourselves and our posterity to the late Dr. Nobel's remaining property, and to all participation in the administration of the same, and also to the possession of any right on our part to urge any criticism upon the elucidations of, or additions to the said Will, or upon any other prescriptions with regard to the carrying out of the Will or the uses to which the means accruing from the bequest are put, which may either now or at some future time be imposed for observance by the Crown or by those who are thereto entitled:

Subject, nevertheless, to the following express provisos:

(*a*) That the Code of Statutes which is to serve in common as a guide for all the corporations appointed to award prizes, and is to determine the manner and the conditions of the distribution of prizes appointed in the said Will, shall be drawn up in consultation with a representative nominated by Robert Nobel's family, and shall be submitted to the consideration of the King;

(*b*) That deviations from the following leading principles shall not occur, viz.:

That each of the annual prizes founded by the said Will shall be awarded at least once during each ensuing five-year period, the first of the periods to run from and with the year next following that in which the Nobel-Foundation comes into force, and

That every amount so distributed in prizes in each section shall under no consideration be less than sixty (60) per cent. of that portion of the annual interest that shall be available for the award, nor shall the amount be apportioned to more than a maximum of three (3) prizes.

In an article reproduced in SCIENCE for August 16, 1907, it is said in regard to the use

of certain parts of the income for the purpose of ascertaining that the prizes are worthily awarded:

> This might be justifiable if the money were spent for this purpose. If the committees used the laboratories and libraries they have established out of the Nobel fund for the purpose of testing the real value of alleged inventions it would do much to promote science and assist in the discovery of struggling genius. But no man is allowed to present his own claims. He must first have the endorsement of scholars occupying certain narrowly specified official positions in his own land.

It would be interesting to know how much the writer of this article referred to knows about the work done at the Nobel Institutes, whether this is done for the purpose indicated or not. It is evident how unpractical it would be if each man presented his own claims to a discovery, and the committee on awards had to test in each case the actual value of the claims. It would be equally interesting to know what method of selection the writer of the article referred to would suggest. To persons with ordinary intelligence it seems fairly evident that the foremost specialists in each country are the best judges as to discoveries in their own line, let it be that these specialists may occupy "certain narrowly specified official positions" only, and do not represent the general public. A popular vote would hardly be the correct method for judging the value of scientific discoveries or achievements in literature.

It must be remembered in regard to the Nobel Institutes that they are not by any means reserved for Swedes, as is often claimed. Paragraph 12 of the Code of Statutes provides that "the adjudicating corporations are at liberty to appoint foreigners, either men or women, to positions at the Nobel Institutes." Of the more than thirty prizes so far distributed only one has been awarded a Swede, and there is no man who could raise any objection in that case. One prize has been given a Norwegian, and this was done not on account of love or relationship, as any one conversant with Scandinavian politics can testify. One prize was awarded a Dane, whose discovery was generally recognized as fully meriting this encouragement. All the other prize-winners have been non-Scandinavians. One American has received a prize so far, and it was not given him on account of nationality, but for his personal accomplishments in the line in which he received a prize.[1]

It can not rightly be claimed that parts of the Nobel funds have been diverted for local purposes, as the institutes are in every way of the most international nature, as all science should be. When the writer in *The Popular Science Monthly* makes the statement that the Nobel Institutes "have been founded in dishonor" he is going too far, and by such an unverified accusation he certainly does himself no credit.

I have repeatedly been approached by countrymen on this side of the Atlantic to reply to some of these attempts at discrediting not only our foremost Swedish scientific institutions; but the Swedish government and nation which have sanctioned the actions of the administrators of the Nobel Fund. I have hesitated to do so, but a recent letter received from a university in the United States brought up the question again, and the new awards of prizes that will be made to-day, on the anniversary of the death of Dr. Alfred Nobel, will probably cause a renewed outburst of comments from newspapers and others. It is well that at least American scientists hear the other view of this question.

Pehr Olsson-Seffer

Mexico City,
December 10, 1907

UNIVERSITY REGISTRATION

To the Editor of Science: In connection with the university registration statistics published in the issue of November 29, I wish to call your attention to the following corrections:

The students of the University of California credited to commerce and architecture constitute a group of students who at other insti-

[1] The recent award of the prize in physics to Professor A. A. Michelson, of Chicago, is further evidence that those concerned in the distribution of the prizes are recognizing true merit, without considering nationality.—P. O.-S.

tutions would probably be classified as students in liberal arts with their major subjects in political science or architecture. On the other hand, Stanford, which was given fourth place in the number of academic students, makes no distinction in its returns between academic students and students in applied science. The men in the undergraduate schools of this institution are very largely registered for major work in the departments of applied science, just as they are at the University of California and at other western institutions.

In the case of Indiana University, the figures for 1902–03 as reported by the registrar's office include all students enrolled in the university from November to November, thus including in each case two freshmen classes. For the years following 1903 the figures include the enrollment from the beginning of the summer term in June to November of the same year, and do not include the new enrollment between November and the following June. Accordingly, the totals for 1902–03 are much too large and the totals for the following years are too small. The actual total enrollments for the university are as follows:

1901–1902	1,285
1902–1903	1,469
1903–1904	1,418
1904–1905	1,538
1905–1906	1,684
1906–1907	1,821

RUDOLF TOMBO, JR.,
Registrar

COLUMBIA UNIVERSITY

ANOTHER FLEA REMEDY

TO THE EDITOR OF SCIENCE: Anent the communication from Dr. L. O. Howard in your issue of November 29, the following preventive, which insures a comfortable night's rest in spite of the proximity of fleas, may be of interest. In sleeping in farmhouses and country hotels in western Oregon, where there was not only a reason to suspect the presence of fleas, but where their presence had been demonstrated beyond question, I secured immunity by pouring a little camphor in solution in the palm of my hand, and rubbing limbs and body with the same. This method is, I believe, in quite general use in infested regions by travelers who have not reached the climax of indifference enjoyed by the natives.

F. L. WASHBURN
MINNESOTA EXPERIMENT STATION,
December 5, 1907

SPECIAL ARTICLES

THE FOSSIL SAWFLY PERGA COLORADENSIS

IN SCIENCE of October 4, p. 446, I recorded a large fossil sawfly from Florissant, apparently referable to the Australian genus *Perga*. In the course of unpacking the Florissant materials, the reverse impression, which I had not seen before, has come to light. It shows certain parts of the wing not clearly visible in the original, and enables me to see that there is a lanceolate cell, traversed by a cross-nervure, after the manner of *Cimbex*. As the marginal cell has no trace of a cross-nervure, wherein it agrees with *Perga* and not with *Cimbex*, the insect finds no place among modern sawfly genera, and may be placed in a new genus *Phenacoperga*.

Phenacoperga coloradensis differs from *Cimbex* not only in the character just mentioned, but in the position of the cross-nervure of the lanceolate cell, which has retreated far toward the base of the wing, so that it is more than twice as distant from the apex of the lanceolate cell as from the base of the wing. This may probably be regarded as a step toward the condition in *Perga*, where the cross-nervure may be considered to have retreated to the very base, and the lower side of the cell then to have failed.

The new genus appears to confirm Konow's classification, wherein *Cimbex* and *Perga* are associated in the same subfamily. According to his system, it would form a new tribe between the Syzygoniides and Cimbicides.

I will take this occasion to refer to *Atocus defessus* Scudder, another extinct genus of sawflies from Florissant. According to Scudder's figure, the insect appears to be anomalous from the total absence of any subcostal nervure. I recently examined the type at Cambridge, and can affirm that the subcostal is

present, although its points of attachment are not clear.

T. D. A. Cockerell
University of Colorado

THE SORGHUM MIDGE

For many years growers of sorghum in our southern states have noted a common failure to produce a full crop of seed. This trouble is generally known as "blast." Many scattered references to this condition may be found in agricultural literature and in correspondence. Different theories as to the cause of this observed sterility have been advanced from time to time. Chief among the agencies which have been regarded as possible causes are fungi, insects and various meteorological conditions, such as excessive precipitation, high humidity, severe drouth and hot winds. Among the growers themselves, it is quite generally held that this sterility results from the washing away of the pollen by heavy rains during the blooming period.

In the spring of 1907, experiments were planned to determine the cause of sterility. The work was largely done at Baton Rouge, La., and San Antonio, Texas. In Louisiana, the writer was assisted by Professor H. R. Fulton, pathologist of the Agricultural Experiment Station, and in Texas by Mr. F. B. Headley, superintendent of the U. S. Experimental Farm at that place. Many of the data on the life history are due to the studies of Professor Fulton.

The first examination of the plants at Baton Rouge, made by the writer late in July, disclosed the presence of large numbers of a small fly on and around the heads. These insects proved to be females actively engaged in depositing eggs within the fertile spikelets. A search of the literature available in the library of the Louisiana Crop Pest Commission brought to light the publication by Coquillet[1] of a new species of Cecidomyiid, *Diplosis sorghicola,* received in sorghum heads in 1895 and again in 1898. A comparison of the insects in hand with this description proved them identical with Coquillet's species. This identity was subsequently confirmed by Professor F. M. Webster.

Observation showed that egg-laying began as soon as the tips of the heads emerged from the boot or upper leaf sheath, and continued until the flowering period was wholly past. Heads in every stage of development, from the beginning of emergence to the close of anthesis, were protected from the midges by means of paper bags. The results of all bagging experiments were in substantial accord. Heads protected from the midge were uniformly fertile, where normal growth continued. Heads exposed during the first half of anthesis and then protected were sterile in the upper portion and well seeded below. Heads exposed until flowering was wholly completed were uniformly sterile when midges were abundant during anthesis, and partly fertile when midges were scarce. From 500 to 1,160 midges were hatched from each of several infested heads. Exposed heads examined a few days after anthesis showed living larvæ lying in close contact with the shrunken and undeveloped ovaries. The injury is due to the absorption of the juices from the young and tender ovary, thus causing development to cease. This absorption is through the body walls of the larva, the ovary being not eaten or otherwise injured though oftentimes discolored. This method of obtaining nourishment is shared also by the larvæ of the closely related wheat midge, *Diplosis tritici,* and by those of the well known Hessian fly. Numerous additional facts concerning the habits and life history of the midge will be presented in a more appropriate place.

Sterility or failure to produce seed in various sorghums is thus shown to be due to the attacks of the Cecidomyiid midge, *Diplosis sorghicola* Coquillet, for which the name, sorghum midge, is here proposed. At Baton Rouge the midge was accompanied by a Chalcid parasite, a species of *Aprostocetus.* According to Professor Webster, this parasite

[1] Coquillet, D. W., "A Cecidomyiid Injurious to the Seeds of Sorghum," U. S. Dept. Agr., Div. of Entomology, Bulletin (New Series), 18: 81–82, 1898.

is not, however, the one noted by Coquillet (*l. c.*) but an entirely new species.

CARLETON R. BALL,
Agronomist in Sorghum Investigations
U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

TWELFTH ANNUAL MEETING OF THE NATIONAL ASSOCIATION OF STATE UNIVERSITIES

THE twelfth annual meeting of the National Association of State Universities was held in Washington, D. C., on November 18 and 19, 1907. In this association upward of forty universities are entitled to membership and thirty-nine are active members; thirty-five universities were represented at the meeting. It was one of the most important meetings of the association ever held in point of attendance, bearing of the topics discussed, business transacted, and investigations ordered.

The president's address, "Some Problems of American Universities," gave a comprehensive view of the field of higher education in America and suggested many vital topics for possible future investigation. The question of a "National University" was again to the front and a definite scheme was endorsed for a non-degree-conferring institution that should add to research opportunities several unique practical functions. A committee of the association in conjunction with a committee of the National Educational Association is charged with the duty of presenting the plan to Congress. A committee met the trustees of the Carnegie Foundation and further discussed the claim of the state universities to the benefits of the retirement fund. At this writing the question is still open. Moreover, a committee on "standardizing" American universities was appointed. This question involves the vital and difficult problems of reorganization of higher education and the action of the association may be of far-reaching importance.

Among the many other questions discussed were "Development of Graduate Schools in State Universities" and "Preparation of High School Teachers."

The Secretary of the Interior and the Commissioner of Education attended part of the meetings and evinced a helpful interest in the problems before the association. A reception was given by the president and faculty of George Washington University.

The relation of state universities to the educational interests of each state, the efficiency of the organization and its representative character make the American Association of State Universities a natural leader in discussing some of the many problems of higher education which are pressing for solution.

JAMES H. BAKER,
President of the Association for 1907
UNIVERSITY OF COLORADO

THE AMERICAN SOCIETY OF AGRONOMY

THE American Society of Agronomy was organized in Chicago on December 31, 1907. According to the constitution, the object of the society shall be the increase and dissemination of knowledge concerning soils and crops and the conditions affecting them.

It is expected that the membership will be composed largely of scientific workers in agronomy. A strong feeling has been prevalent for some time that an opportunity is greatly needed for college and station men to meet and discuss methods of experimentation and instruction in agronomy.

Provision has been made for including as charter members all who join the society before July 1, 1908. Arrangements were also made by which local sections may be established in any part of the country on application of three members of the society. The agricultural colleges may thus have local organizations for discussion of agronomic subjects.

By resolution the society expressed its desire to assist the Society for Promotion of Agricultural Science in bringing about affiliation of all the scientific agricultural organizations.

The officers for the present year are as follows:

President—M. A. Carleton.
First Vice-president—C. P. Bull.
Second Vice-president—J. F. Duggar.
Secretary—T. L. Lyon.
Treasurer—E. G. Montgomery.

Time and place of meeting and form of publication are to be decided later.

T. L. Lyon,
Secretary

Ithaca, N. Y.,
January 10, 1908

THE WORK OF THE MAGNETIC SURVEY YACHT "GALILEE" IN THE PACIFIC OCEAN DURING 1907

The early part of the year found the *Galilee* on her way to the Marquesas Islands, having left San Diego, California, on December 22, 1906, with the following scientific personnel on board: W. J. Peters, commander; Messrs. J. C. Pearson and D. C. Sowers, magnetic observers, and Dr. G. Peterson, surgeon and recorder. Captain J. T. Hayes, as heretofore, was the sailing master.

From the Marquesas Islands, the route followed to Shanghai, touched at Tahiti (Society Islands), Apia (Samoan Islands) and Yap (Caroline Islands); Shanghai was reached on May 8. At all of the ports visited special examinations with regard to the distribution of the magnetic elements were made and comparisons secured, whenever possible, between the *Galilee* magnetic instruments and magnetic observatory standards. In addition, magnetic observations were made at sea whenever conditions permitted.

Leaving Shanghai on May 31 course was set for Sitka, Alaska, where the vessel arrived on July 15. Here she was inspected by Dr. L. A. Bauer, and some instrumental changes decided upon in consultation with the commander, Mr. Peters. At this port Mr. J. C. Pearson, who had been continuously on sea duty for a year and a half, was relieved and assigned to important magnetic work in the Yukon territory. In his place on board ship was assigned Mr. P. H. Dike, who in addition to taking part in the regular magnetic observations will likewise attempt special experimental work in atmospheric electricity.

After having completed the required shore operations at Sitka, the *Galilee* set out once more, under the command of Mr. Peters, for a cruise extending this time over both the North and the South Pacific Ocean. Leaving Sitka on August 10 she arrived at Honolulu on August 28. Here again shore magnetic observations were made and instruments were tested and compared at the Coast and Geodetic Survey Magnetic Observatory near Honolulu.

Leaving Honolulu on September 26, the *Galilee* was sighted off Midway Island on October 6 on her way to Jaluit, of the Marshall Islands, and she finally arrived at Lyttleton, near Christchurch, New Zealand, on December 24, having been delayed somewhat in her progress by calms.

It is expected that she will leave the last named port about January 15 for Callao, Peru, where she is due to arrive early in March. From thence she will return to her home port, San Francisco, about May 1. The aggregate length of the cruises of the *Galilee* since August 1, 1905, will then have amounted to about 65,000 miles, embracing the Pacific Ocean from the American coast to the Asiatic coast, and from the Aleutian Islands down to New Zealand.

A complete determination of the three magnetic elements (magnetic declination, magnetic inclination, and intensity of magnetic force) has been secured at sea, on the average, about every 200 or 250 miles along the entire route, besides numerous magnetic results having been secured at ports and islands visited.

Owing to the high efficiency reached by Mr. Peters's party and because of the promptness with which the records of observations are transmitted, the complete reduction of the work can be kept almost apace with the observational work. It is confidently hoped that all the results obtained can be put in published form shortly after the termination of the work at San Francisco next May.

To say nothing of the interesting and important scientific results growing out of this work, mention may be made at present of but one result—one of great practical importance to navigational interests. With the aid of the data furnished the United States Hydrographic Office by the Carnegie Institution of Washington, it was possible to issue last spring a new chart of the "Lines of Equal Magnetic

Variation" (Magnetic Declination). It was found that in the Pacific Ocean the charts previously possessed were erroneous along certain well traversed routes by as much as three or five degrees, and that systematically at times. Hence these errors were of sufficient magnitude to be taken into account in practical navigation.

ELIZABETH THOMPSON SCIENCE FUND

THIS fund, which was established by Mrs. Elizabeth Thompson, of Stamford, Connecticut, "for the advancement and prosecution of scientific research in its broadest sense," now amounts to $26,000. As accumulated income is now available, the trustees desire to receive applications for appropriations in aid of scientific work. This endowment is not for the benefit of any one department of science, but it is the intention of the trustees to give the preference to those investigations *which can not otherwise be provided for,* which have for their object the advancement of human knowledge or the benefit of mankind in general, rather than to researches directed to the solution of questions of merely local importance. The trustees are disinclined, for the present, to make any grant to meet ordinary expenses of living or to purchase instruments, such as are found commonly in laboratories. Decided preference will be given to applications for small amounts, and grants exceeding $300 will be made only under very exceptional circumstances.

Applications for assistance from this fund, in order to receive consideration, *must be accompanied by full information,* especially in regard to the following points: (1) Precise amount required; (2) exact nature of the investigation proposed; (3) conditions under which the research is to be prosecuted; (4) manner in which the appropriation asked for is to be expended.

All applications should be sent at once to the secretary of the board of trustees, Dr. C. S. Minot, Harvard Medical School, Boston, Mass.

SCIENTIFIC NOTES AND NEWS

DR. W. W. KEEN has been elected president of the American Philosophical Society, Philadelphia, succeeding Dr. Edgar F. Smith, who declined reelection.

AT the recent meeting of the American Society of Zoologists, Eastern Branch, held at the Sheffield Scientific School of Yale University, the following officers were elected: *President,* Dr. William Morton Wheeler, American Museum of Natural History; *Vice-president,* Professor Herbert S. Jennings, Johns Hopkins University; *Secretary-Treasurer,* Dr. Lorande Loss Woodruff, Yale University; *Member of the Executive Committee,* Professor Gilman A. Drew, University of Maine.

AT the recent Madison meeting of the American Economic Association Professor Simon N. Patten, of the University of Pennsylvania, was elected president, to succeed Professor Jeremiah W. Jenks, of Cornell University.

M. GONNESSIAT, of the Paris Observatory, has been appointed director of the Observatory of Algiers.

PROFESSOR CORNIL, of Paris, having reached the age limit of seventy years, has been retired from the chair of pathological anatomy and histology, which he may be said to have first founded in France.

DR. DAVID HILBERT, of the University of Göttingen, has been made a member of the Bavarian-Maximilian Order for Science and Art.

LORD BRASSEY has been elected a corresponding member of the geographical section of the French Academy of Sciences in succession to the late M. Oudemans.

PROFESSOR RAPHAEL MELDOLA, F.R.S., past president of the Chemical Society, has been elected president of the Society of Dyers and Colorists, in succession to the late Sir W. H. Perkin.

THE University of St. Andrews has resolved to confer the honorary degree of LL.D. upon the following scholars, on February 16: Lord Avebury; Mr. Francis Darwin, president-elect of the British Association; Mr. Philip Norman, treasurer of the Society of Antiquaries; Sir E. J. Poynter, Bart., president of the Royal Academy; Mr. Charles Hercules Read, past president of the Anthropological Institute; and Principal MacAlister, Glasgow.

The University of Cambridge has conferred the honorary degree of M.A. upon Mr. Sidney Herbert Ray, assistant master at St. Olga Street Council Schools, Bethnal Green, in recognition of his study of Oceanic languages.

The Vienna Academy of Sciences has made an appropriation of $300 to Dr. Robert Falta for his work on diabetes.

Professor W. A. Kellerman, of the Ohio State University, is now in the republic of Guatemala prosecuting his fourth mycological expedition to that country, assisted by students H. E. Barber, S. B. Stowe and J. F. Zimmer. The party will collect parasitic fungi and material in related branches of natural history, returning about April 1.

Dr. George A. Dorsey, curator of Anthropology in the Field Museum of Natural History of Chicago since 1897, has begun a long trip in the interests of the museum. He visits first the leading museums on the continent and then proceeds to Ceylon by way of Egypt. In Ceylon he will study the Rock Veddahs, considered the lowest in culture of all the inhabitants of the earth. He then crosses to Southern India and on to Siam, Sumatra and Java. From Java he proceeds to Australia and then to New Zealand where he will study the Maoris. His next objective will be various islands of the Melanesian group. On his way home he will stop at the Philippine Islands to explore some of the little known parts of Mindanao and Mindoro.

The Herbert Baxter Adams prize of $200.00 offered biannually by The American Historical Association for the encouragement of historical research and offered in 1907 for the best unpublished monograph in the field of European history, has been awarded to William Spence Robertson, of Western Reserve University, and Edward B. Krehbiel, of the University of Chicago. The prize is to be divided between them. The prize-winning theses will be published by The American Historical Association both as separate publications and as parts of the annual report of the association. Dr. Robertson's thesis was on "Francisco de Miranda and the Revolutionizing of Spanish America." Professor George L. Burr, of Cornell University, was acting chairman of the committee on award.

The secretary of the Lamarck memorial, adding to his former report, records that he has received contributions from the following institutions and societies: Philadelphia Academy of Sciences, N. Y. Zoological Society, American Paleontologists, American Zoologists, American Naturalists, American Museum of Natural History, Washington Biological Society; and from the following individuals: Messrs. W. S. Marshall, George F. Eaton, Metcalf, Townsend, Hargitt, C. W. Dodge, Davenport, Conklin, Hussakof and Ball.

The funeral of Lord Kelvin at Westminster Abbey, on December 23, was impressive in character. The pall-bearers were: The Lord Rayleigh, O.M., president of the Royal Society; The Right Hon. J. Morley, O.M., secretary of state for India; Sir Archibald Geikie, K.C.B., president of the Geological Society; Professor A. Crum Brown, Royal Society of Edinburgh; The Master of Peterhouse, Cambridge; Sir J. Wolfe Barry, K.C.B., Institution of Civil Engineers; Sir Edward H. Seymour, O.M., admiral of the fleet; M. Gaston Darboux, perpetual secretary of the Academy of Sciences of France; The Lord Strathcona and Mount Royal, high commissioner for Canada; Sir George Darwin, K.C.B., University of Cambridge; Dr. McAlister, principal of the University of Glasgow; Dr. R. T. Glazebrook, Institution of Electrical Engineers.

A memorial meeting in honor of Lord Kelvin was held at the United Engineers Building, New York City, on January 12, under the auspices of the American Institute of Electrical Engineers. Mr. Henry G. Stott presided, and among those who made addresses were Dr. Elihu Thomson, Rear Admiral George W. Melville and Professor E. L. Nichols, of Cornell University.

Professor Boeckh, an eminent medical statistician and emeritus director of the Berlin Statistical Bureau, has died at the age of eighty-three years.

THE fourth lecture in the Harvey Society course was delivered at the New York Academy of Medicine building on Saturday evening, January 11, 1908, by Professor Ernest H. Starling, of the University of London. Subject: "The Chemical Control of the Body."

THE Lees and Raper memorial lecture, 1908, will be delivered in the Town Hall, Oxford, by Mr. William McAdam Eccles, M.S., F.R.C.S., on February 4. Subject: "The Relation of Alcohol to Physical Deterioration and National Efficiency."

AT the request of the New York Physics Club, Professors Crocker and Sever and Mr. Arendt, of the department of electrical engineering of Columbia University, will give to its members a series of demonstrations on electrical engineering, so far as it bears upon high-school physics. These lectures will be free and will be given in the engineering building of Columbia University on Tuesday afternoons from 4 to 5:15 o'clock, February 4 to March 24, inclusive. It is expected that they will be open to all teachers of secondary schools as well as to members of the New York Physics Club.

THE Western Reserve University lecture course now being announced includes lectures upon political, sociological, medical and scientific subjects. Dr. James Elbert Cutler, formerly of the University of Michigan, and now associate professor of sociology upon the newly established Selah Chamberlain Foundation at Western Reserve, opened the course Tuesday evening, January 14, with his lecture, "Lynching as an American Practise." Professor Cutler has made a special study of lynching, and has contributed articles upon the subject to both northern and southern publications. Other lectures of the course are to include "The Results of the Anti-Tuberculosis Movement," by Dr. John H. Lowman, of Western Reserve Medical College, date to be announced later: "The More Recent Developments in Astronomy," by President Charles Sumner Howe, of the Case School of Applied Science, March 3, and "Municipal Home Rule: the Relation of the City and the State," by Dr. Augustus Raymond Hatton, of Western Reserve University, March 17. Dr. Hatton is associate professor of political science upon the M. A. Hanna Foundation. The lectures are free and are to be given in the physical laboratory on the Adelbert College Campus.

THE Sheffield Scientific School of Yale University announces its forty-second annual Sheffield lecture course, to begin January 17, 1908. Following is a list of the lecturers and their subjects, with the dates:

January 17—"Mars as seen from the Andes," by Professor David Todd.

January 24—"Northern Mexico: its Deserts, Plateaus and Canyons," by Dr. Edmund Otis Hovey.

January 31—"Nature Study in relation to protecting and propagating American Game Birds," by Professor Clifton F. Hodge.

February 7—"Personal Experiences in Alaska and the Chilkoot Pass," by Mr. Alfred H. Dunham.

February 14—"Modern Long-span Bridges, with special reference to the Quebec Disaster," by Mr. Frank W. Skinner, C.E.

February 21—"Persian Travels," by Dr. William Lord Smith.

February 28—"Heredity in Man and the Lower Animals," by Dr. Charles B. Davenport.

March 6—"Rare Earth Industries," by Mr. Harlan S. Miner.

March 13—"Silk, Natural and Artificial," by Professor Charles F. Chandler.

March 20—"History and Habits of the Fur Seal," by Mr. Frederic A. Lucas.

THE U. S. Civil Service Commission announces an examination on April 1, 1908, to fill several vacancies in the position of micro-analyst (either sex), at $1,500 per annum, and at lower salaries, depending upon the qualifications shown, in the Bureau of Chemistry, Department of Agriculture.

MR. ENGLEBRIGHT has introduced a bill in the House of Representatives to establish in the Department of the Interior a Bureau of Mines. The bill has been referred to the committee on mines and mining.

A COPY of a decree issued by the provisional governor of Cuba has been transmitted by the Department of State to the Department of Commerce and Labor. It names a commission of fourteen members, headed by Rafael

Fernandez de Castro, president of the Agrarian League of the island, and empowered to prepare a report and submit a draft of a law for the amelioration of agricultural conditions in Cuba.

Consul-General Richard Guenther, of Frankfort, says it is reported that a Hamburg joint stock company has purchased a large tract of land along the mouth of the Elbe at Cuxhaven, where power works are to be erected. The action of the ebb and flow of the tide is to be employed in generating electric energy to be used in factories about to be established. The works will also furnish electric power to the town of Cuxhaven and other towns in the vicinity. The daily capacity of the plant will reach 14,000 horse power.

The French Administration des Postes et Télégraphes is, according to the Paris correspondent of the London *Times*, engaged in making some interesting experiments with a view to the improvement of telephone communication. On an underground cable between Lille and Roubaix a certain number of self-induction coils on the system of Professor Pupin, of Columbia University, have been intercalated. As was found to be the case in America, the results obtained have been excellent, and there is some talk of greatly increasing the use of these coils on a number of other telephone lines.

UNIVERSITY AND EDUCATIONAL NEWS

Mr. Andrew Carnegie will erect a $50,000 building for Bates College for the study of science, providing a similar sum is raised to support the department.

Harvard University has received from the trustees under the will of Miss Harriet N. Lowell the sum of $2,000, this being the first annual payment of a part of the income of her estate in accordance with a provision by which the money will be for surgical research.' In addition to this immediate benefit, the university has the remainder of the estate, subject to the life tenancy above mentioned. The university has received from Mr. Francis Skinner $2,500 as his final payment on account of his gift of $5,000 for the purchase of books for the Arnold Arboretum, in memory of his father, Francis Skinner, of the class of 1862.

Columbia University has received for the equipment of the Department of Mining and Metallurgy three gifts of $2,500 each from estate of D. Willis James, Adolph Lewisohn and the Nichols Copper Company.

Steps have been taken by the authorities of the University of Wisconsin to increase the practical value of the instruction in agriculture by establishing a full two-year course to include the maximum amount of scientific and practical work. The present four-year course in agriculture has been revised with view to introducing into the first two years a number of subjects bearing directly upon farming, instead of confining the first years of the course as heretofore to purely scientific work. Graduation from high school or equivalent preparation will be required for entrance to the new two-year course, as well as to the present four-year course. At least six months of practical farm experience will be required for the completion of either of these courses.

According to a decree issued by the ministry of education, ceremonial matriculation is henceforth to be dispensed with in Austrian universities.

Dr. Albert Ross Hill has accepted the presidency of the University of Missouri to succeed President R. H. Jesse. Dr. Hill was dean of the College for Teachers at Missouri until last year when he accepted the deanship of the College of Arts and Sciences at Cornell University.

Dr. E. O. Lovett, professor of mathematics at Princeton University from 1900 to 1905 and since professor of astronomy, has resigned to accept the presidency of the institute established at Houston, Texas, by the late William M. Rice, with an endowment, which after long litigation is said still to amount to over $2,000,000.

Mr. A. T. Stuart has been appointed superintendent of schools in Washington to succeed Dr. William E. Chancellor, who has been dismissed by the Board of Education. The main charge against Dr. Chancellor appears to have been lack of judgment and tact.